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JOHN D. GREGSON

CANADA DEPARTMENT OF AGRICULTURE
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INTRODUCTION

Ticks belong to the superfamily Ixodoidea of the order Acarina. The adults are eight-legged creatures, one-sixteenth to nearly one-quarter of an inch long when unfed. They are distinguished from the spiders by having a fused body and from the mites by their mouth parts, which are grouped to form a movable capitulum. They are divided into two families, the Argasidae and the Ixodidae. The Argasidae lack a hard dorsal scutum, or shield, have a granular integument, and have breathing pores, or spiracles, usually anterior to the bases of the hind legs. The mouth parts are ventral and not visible from above, and the sexes are similar. These ticks are usually nocturnal and are rapid feeders, resembling bed bugs in this respect, though easily distinguished from them by having eight instead of six legs. Only five species, representing three genera, are known to occur in Canada.

The Ixodidae are characterized by the presence of a hard scutum that covers the foremost portion of the dorsum of the female and all that of the male. In addition, the mouth parts are terminal, and the spiracles are posterior to the hind legs. This family is by far the larger; 23 of its species, from four genera, have been collected in Canada.

In this paper all known species of ticks in Canada are discussed in such a way that students may become familiar with their identities and known biologies. Detailed descriptions of species, listing structures of little or no comparative significance, are omitted. For these the reader is referred to the excellent bulletins of Cooley (1938, 1946a) and Cooley and Kohls (1944a, 1945) covering the Ixodoidea of the United States and areas northward. Further reference is made to the host and distributional records of Bishopp and Trembley (1945). Notes on the biologies are largely drawn from data accumulated at the Kamloops laboratory, where the bulk of the material was studied. Pertinent notes from other sources have been included where local data have not been at hand.

There are still gaps in the knowledge of life-histories of species in Canada and many problems exist in other portions of their biologies. It is hoped that this paper will serve to stimulate further endeavours in these fields.

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ECONOMIC IMPORTANCE

On Man

Though practically all the ticks of Canada are primarily parasites of wild animals, man is frequently the host of the more important species. Because of this, their role in the transmission of certain diseases in nature to humans is of importance to the welfare of mankind (Parker *et al.*, 1937, and Miller, 1947). The Rocky Mountain wood tick, also known as the spring or the paralysis tick, *Dermacentor andersoni,* is by far the most significant species in this connection, since it plays a primary part in the maintenance of at least the first three of the following diseases common in the northern half of North America.

Tick paralysis is the most important of the diseases associated with ticks in Canada. This condition is a flaccid, afebrile, ascending, motor paralysis that may be produced in man and domestic animals by the attachment of certain species of ticks. The disease is known to occur in Europe, South Africa, Australia, and North America. On this continent, where its incidence largely depends on the presence and seasonal activity of the principal causative tick, *Dermacentor andersoni,* it is usually confined to the Pacific northwest and is predominantly a spring and early-summer disease. However, there are records of its appearance in man and dogs in the eastern and southern United States, where it has been produced by *D. variabilis, Amblyomma maculatum* Koch, and *A. americanum* L.

Man appears to be particularly susceptible to the disease and may be paralysed by a single female tick. The symptoms, as a rule, do not appear until the tick has been attached and engorging for about six days. Paralysis then becomes evident as an unsteadiness in the legs, resulting in a weaving and wobbly gait. Reflexes are lost, but sensation and apprehension may be present. The paralysis ascends during one to two days from its onset, after which the victim may be immobilized. Further progress results in respiratory failure and death. There is but slight increase in temperature. The pulse may become rapid. Although the symptoms are of a progressive nature, they are halted by the removal of the tick, after which they usually disappear rapidly, rarely leaving any after-effects.

In human beings, tick paralysis is not uncommonly mistaken for poliomyelitis, Landry's disease, and even drunkenness. However, the presence of an ascending paralysis and a history of exposure to ticks, and particularly the presence of one or more feeding ticks, should suggest the cause and nature of the symptoms. Full consideration should be taken of the delayed development of paralysis after the attachment of the tick, as during this period the patient may have travelled to areas remote from natural tick habitats.

Though there is considerable speculation concerning the exact nature of the disease, it is generally believed to be due to a neurotoxin that is secreted by the salivary glands of the feeding female tick. There is evidence that there are variations in host susceptibility within species or in tick virulence or both, since not all animals infested become paralysed (Gregson, 1952). Curiously, the disease is produced more frequently by ticks on the western side of the Rocky Mountains than by those on the eastern side. It is also more common in the northern portion of the tick's distribution, more cases having been recorded from British Columbia than from the rest of the continent (Jellison and Gregson, 1950).

Approximately 240 human cases of tick paralysis have been recorded at the Kamloops laboratory from British Columbia. Of these, because of failure to recognize the symptoms in time and to remove the tick, 27 (about 11 per cent) ended fatally. It is probable that many more cases remain unrecorded. The disease has been discussed at greater length by Mail and Gregson (1938), Gregson (1943), and Abbott (1943).

Rocky Mountain spotted fever is an acute, specific, non-contagious, tick-borne disease caused by the intra-cellular rickettsia *Rickettsia rickettsii* (Wolbach) Brumpt. It is endemic in the northwestern United States, and has been recorded in all but four states of the U.S.A. In Canada it occurs in British Columbia, Alberta, Saskatchewan, and questionably in Manitoba (Parker and Oliphant, 1950). It is most virulent in southern Alberta, where, in the endemic area, about two per cent of the vector ticks (*Dermacentor andersoni*) have been reported to be infected (Bow and Brown, 1945). Of the nine known and four suspected cases recorded from this province, five ended fatally (Bow and Brown, 1952).

Although the spotted fever organism has only once been definitely isolated from wildlife (Gould and Miesse, 1954) most species of rodents and certain carnivores probably passage the disease from tick to tick (Parker, 1933). The rickettsia of infected ticks may persist to successive stages of the parasites and even be transmitted through the eggs to the next generation. When man is accidentally the tick host he may become infected. As a rule a tick does not transfer infection until it has fed for several hours.

Although the ticks *D. andersoni* and *D. variabilis* are the most important vectors of the disease where man is concerned, the rabbit tick, *Haemaphysalis leporis-palustris,* plays an important part in maintaining the organism in nature. *Otobius lagophilus* has also been proved a vector in Mexico (Silva-Goytia and Elizondo, 1952). Laboratory experiments (Parker *et al.,* 1933) have shown that, of the remaining species of ticks in Canada, *Rhipicephalus sanguineus* is also a potential vector.

The symptoms of the disease in man are characterized by fever, severe headaches, and finally a rash over the whole of the body. The incubation period varies from two to ten days. In cases not treated with antibiotics, death may result within three to five days.

Colorado tick fever is a febrile virus disease that appears to be transmitted mainly by *D. andersoni* but that has been found in the United States in *D. albipictus* (Rocky Mountain Laboratory, unpublished data), *Otobius lagophilus* (Philip *et al.,* 1953), and other species. The symptoms are somewhat similar to those of spotted fever but milder, the fever is remittent, and there is no rash. Malaise, chills, severe headaches, and temperatures up to 105°F. may accompany the attack, but the disease is seldom fatal. During recent years this disease has been found to be present in *D. andersoni* in wide areas of the northwestern United States, and is now considered to be the most common tick-borne disease in this area (Rocky Mountain Laboratory, unpublished data). In Canada this disease has recently been isolated from *D. andersoni* from Banff, Alta. (J. H. Brown, unpublished data). It is probably widely spread in the western provinces, but because of its relatively mild effect on humans has escaped notice.

Tularaemia is a bacterial disease that occurs mainly in rabbits, but also infects certain rodents, ungulates, carnivores, game birds, and man. It is caused by a pleomorphic organism, *Pasteurella tularensis* (McCoy and Chapin) Bergey *et al.,* which is transmitted by such arthropod vectors as ticks, lice, fleas, and biting flies, and by the contact of skin and mucous membranes (eyes) of susceptible animals with infected material. *D. andersoni, D. variabilis,* and the rabbit tick, *H. leporis-palustris,* have been shown to be natural vectors of

this disease, which may be passed to new hosts by the tick's bite or by its faeces. There is also evidence that in some species of ticks tularaemia may be transmitted through the eggs to the following generation (Parker, 1934). Natural infections have also been demonstrated in *I. pacificus* (*nec I. ricinus californicus* (Banks), Davis and Kohls, 1937), and *H. chordeilis,* although transmission has not been proved in these species. Tularaemia in man is an acute infection, which, after an incubation period of two to seven days, is characterized by chills, fever, aching, prostration, and rapid loss of weight. The acute stage lasts for two to three weeks, during which period there is usually an ulceration at the site of the infection accompanied by enlargement and possible suppuration of the lymph nodes. Convalescence is slow and may last for several months. The disease has been recorded from Nova Scotia; and from Ontario, where there have been well over 50 cases in 14 years (Bequaert, 1946). In Saskatchewan, through provincial and federal surveys, it has been found in *D. variabilis* from Carlyle Lake, and in *D. andersoni* from south-western parts of the province. In Alberta, Brown (1943) states that the disease is well established, the infection having been demonstrated in ticks (*D. andersoni*), jack-rabbits (*Lepus townsendii companius* Hollister), domestic sheep, Rocky Mountain bighorn (*Ovis c. canadensis* Shaw), and man. Other references to the disease in Alberta are contained in the reports of Gwatkin *et al.* (1942) and Bow and Brown (1943). In British Columbia, tularaemia has frequently been isolated from rabbits (*Lepus americanus* ssp.) from the North Thompson Valley and from the Kootenay and coast districts, by the Department of National Health, Kamloops, B.C.

Relapsing fever is a spirochetal infection characterized by a diminishing series of febrile periods of two to five days' duration, alternating with longer afebrile periods. Although the illness may be serious, it is not likely to be fatal. The causative organism is usually transmitted by certain species of the genus *Ornithodoros*; Davis (1942a and 1952) has found that in North America a marked degree of specificity exists between different "strains" of the disease and the corresponding species of infected ticks. In Canada the disease was first recorded by Palmer and Crawford (1933), who cited six human cases from the Kootenay district of British Columbia. Hearle's (1934) speculation that soft ticks might be the vectors has been strengthened by the subsequent discovery of *O. hermsi* in British Columbia (Gregson, 1949a). Although no Canadian specimens of this tick have been found to be infective, this species is a proved vector of the disease in several states of the U.S.A., including Oregon and Idaho (Davis, 1942b). Another vector of relapsing fever, *O. parkeri* Cooley, has been taken as far north as Washington and may yet be found in British Columbia.

Q fever is an acute, specific, often serious, and occasionally fatal rickettsial disease of man. The causative agent, *Coxiella burnetii* (Derrick) Bengtson (formerly called *Rickettsia diaporica* by Cox), is abundant in cows and their milk in various parts of the world, but the mode of transmission to man is still not clear (Heubner *et al.,* 1949).

D. andersoni and *R. sanguineus* are among the ten species of ticks that have been found naturally infected with the disease in the United States, Australia, and Morocco (Davis 1953; Parker and Sussman, 1949). Other known natural reservoirs include goats and sheep. There is at least one instance where a Montana man was probably infected through contact with ticks in nature (Eklund *et al.,* 1947). Outbreaks of the disease in man in the United States have usually been associated with the proximity of livestock. The symptoms are characterized by sudden onset, fever, headache, weakness, malaise, chills, and sweats. A pneumonitis occurs in the majority of cases. The severity and duration of the disease vary. To date, no cases have been reported in Canada.

St. Louis encephalitis is a filtrable virus disease transmissible from poultry and other reservoirs to man. It has been reported from various parts of the western half of the United States as far north as North Dakota. Although mosquitoes are known to be natural vectors, it has also been shown by Blattner and Heys (1944) to be transmitted experimentally by *D. variabilis*. Because of its ability to transmit the virus through several generations, this, and possibly other ticks, may play a part in the maintenance of the disease in nature.

Other pathological conditions of various types may also be caused by ticks. The most common is associated directly with the tick's bite. Though in most instances, because of their short mouth parts, the *Dermacentor* ticks may be removed with little difficulty and rarely leave any infection, there are occasional cases of an apparent healing of this species' bite, with a reappearance of the irritation after several months (Mail and Gregson, 1938). In the *Ixodes* species the longer hypostome frequently breaks off, resulting in a painful, slow-healing ulcer at the site of the bite. Species of this genus also have more toxic secretions, and punctures of even short duration often produce an intense swelling, inflammation, and itching over an entire limb (Gregson, 1942d). The reaction may be even more striking in the case of argasid ticks: one person from Cultus Lake, B.C., reported severe shock, verging on coma following the bite of *Ornithodoros hermsi*. Also, references to erysipeloid swellings resulting from the bites of *Argas* and *Ornithodoros* spp. in Europe and Africa are made by Philip (1953).

A potentially dangerous species is the brown dog tick, *Rhipicephalus sanguineus*. This cosmopolitan species in recent years has invaded Eastern Canada. Although normally a parasite of dogs, it may bite man, and because of his close association with dogs there are frequent opportunities for the transmission of disease to him. In the Old World it is the vector of boutonneuse fever among dogs and man. It also transmits canine piroplasmosis, which is not only present in Europe, Asia, and Africa but has also been found in the southern United States, Panama, and Brazil (Cooley, 1946a). This tick is, moreover, suspected to be capable of transmitting Rocky Mountain spotted fever and is considered to be an important vector of this disease in Mexico (Varela and Ortiz, 1949). Miller (1947) cites it as being capable of transmitting at least 11 diseases of man and animals.

Ticks also evoke psychological terror among many people, and although much of this is unwarranted the state of anxiety so produced has in at least one instance (Spencer, 1945) driven a person to insanity. How much better could the victim have relieved his emotions like the friend quoted by Cockle (1916) who "marooned a tick on the top of a bare rock in the middle of a sawmill pond. Every morning, hail, rain, or shine, he would row over to this rock to look at the tick and curse it with some of the choicest vernacular to be met with, even in the pioneer West. The tick remained marooned on this rock for over three months."

The effects of a tick's bite on man have even involved legalities. The wife of a victim of spotted fever in Oregon, U.S.A., was awarded an additional $25,000 under a double indemnity clause in a life insurance policy when a jury decided that the fatal bite of the tick constituted "bodily injury through external violent and accidental means" (newspaper clipping).

On Domestic Animals

In British Columbia ticks rank high among pests of livestock, and where their effects are felt by the rancher they play an important part in his operations. *D. andersoni* causes the most concern since attacks by this species may cause serious losses in cattle and sheep from tick paralysis. Sheep and dogs, like human beings, may be paralysed by single ticks, which, if not removed in

time, may cause their deaths. Cattle tolerate large numbers and, as a rule, those that become paralysed are infested with clusters of more than 100 males and females. As in human tick paralysis, the symptoms usually disappear soon after the parasites are removed. However, stricken animals that are not treated promptly may die from exposure and secondary effects. The severest outbreaks of this disease in Canada have occurred in the Nicola district of British Columbia, where in 1930, 1934, and 1944, 100, 200, and 400 cattle respectively from herds of 900, 638, and 1,230 were paralysed, with losses of 65, 26, and 50 head (Moilliet, 1937; records at the Kamloops laboratory). Milder outbreaks in both cattle and sheep occur each year, and, although only a few animals may be involved, the losses in small holdings are still relatively great. In addition to the direct loss from animals dying during tick paralysis outbreaks, there is the cost of labor, the worry, the emergency deticking treatments, and the less noticeable loss of weight in stock due to handling and tick irritation. Even where ticks are merely known to be present, there is the annual fear of losses, with the resulting holding back of livestock from infested spring pastures at a time when good feed is badly needed.

Tick paralysis in livestock east of the Rocky Mountains is rare, and appears, to date, to be confined to a few cases in sheep, cattle, and horses in Alberta (Brown, 1944) and Saskatchewan (Davidson, 1941).

The second most serious tick pest of livestock is the winter tick, *D. albipictus*. Horses are mainly affected, and, after five to six months of severe infestations, often become so emaciated as to be of little value for farm purposes. Although in British Columbia cattle rarely become seriously infested by this tick, Cameron and Fulton (1927) reported a loss of 63 cattle (and 44 horses) out of 150 head of mixed livestock in northern Saskatchewan.

Among ticks that occur in Canada and have so far not proved troublesome, but that are serious pests of domestic animals elsewhere, are the spinose ear tick, *Otobius megnini*, and the fowl tick, *Argas persicus*.[1]

Although apparently few of the human tick-borne diseases affect domestic animals, the disease-transmitting potentialities of ticks among livestock should not be overlooked. Jellison and Kohls (1950) and Philip *et al.* (1935) cite outbreaks of tick-borne tularaemia in sheep causing losses of hundreds of animals. Such outbreaks are also an occupational hazard for sheep herders and shearers (Jellison and Kohls, 1953).

Equine encephalomyelitis is a disease of considerable economic importance among horses in Canada. It is caused by a filtrable virus, and is also transmissible to man, in whom it may cause a severe and sometimes fatal illness. Although mosquitoes are suspected to be the usual vectors, Syverton and Berry (1941) have shown that under experimental conditions the western type of the disease can be transmitted by the bite of *D. andersoni* (=*venustus*), in which the virus may be inherited for two successive generations.

Caseous lymphadenitis, a disease of sheep and deer caused by *Corynebacterium ovis* Bergey *et al.* (=*C. pseudotuberculosis* (Buchanan) Eberson), is common in parts of British Columbia. The condition is characterized by the presence of caseo-purulent glandular lesions in the bodies and limbs of infected animals. Whether ticks are implicated in its transmission is not known, but Humphreys and Gibbons (1942) demonstrated the heredity transmission of this organism in infected specimens of *D. albipictus*, and although this tick has not been taken from domestic sheep there are ample opportunities for infestations from tick-infested and infected deer.

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[1] *O. megnini* caused the deaths of two and probably five cattle in the Shuswap Lake area, British Columbia, in 1955.

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Anaplasmosis, a disease caused by a haematozoan parasite of red blood cells, is another disease of potential importance to the livestock industry of Canada. Normally a subtropical disease of bovine animals, it has spread northward from the southern and central United States into Montana and Idaho. *D. andersoni, D. albipictus,* and *D. variabilis* have been proved capable of spreading this disease (Davidson, 1941). The symptoms range from mild dietary disturbance to chronic anaemia and jaundice; the mortality varies from 30 to 50 per cent.

Toxoplasmosis is a widespread and sometimes severe infection of man and animals in the United States. The causative agent, a nucleated, crescent-shaped organism, shows a predilection for nervous tissue, but may also become encysted in other portions of the body. Although the mode of transmission is a matter of conjecture, transference by blood-sucking arthropods has been postulated, and Woke *et al.* (1953) have shown that three ticks, *D. variabilis, D. andersoni,* and *Amblyomma americanum* (L), may transmit the disease under laboratory conditions. They state: "Infection in *D. andersoni* appears to have been carried through the eggs from infection as larvae, nymphs, or adults to all three stages of the succeeding generation, and from the nymphs to hosts through the bite".

Q fever has been mentioned as a disease of humans that has cattle and ticks among its natural reservoirs. Although cattle are apparently unharmed by this infection, the importance of the organism as an occupational hazard in the dairy and beef industry cannot be ignored.

Other foreign tick-borne diseases of livestock, of which louping ill of sheep and red water and splenic fever of cattle are examples, serve to emphasize the potential importance of ticks when it is considered that at least some of the species of ticks in Canada would probably be capable of acting as vectors should such diseases be introduced into this region. Philip (1939) lists nine tick-borne diseases of animals in North America alone. *D. andersoni* has also been shown to be capable of transmitting *Salmonella enteritides* (Parker and Steinhaus 1943).

As parasites of pets, *Rhipicephalus sanguineus* and *Ixodes pacificus* are sources of annoyance locally in Eastern and Western Canada, respectively, where dogs in infested areas may have to be searched daily for ticks.

On Wildlife

It is among wildlife that the true relationships between ticks and their natural hosts are found. In many instances, where the tick is specific and the host is of little economic importance, the effect of the parasite is unnoticed. Where man has an interest in the hosts, such as game birds and mammals, the part played by ticks is readily apparent.

The most spectacular losses are caused by *D. albipictus;* after severe winters and poor grazing, large numbers of deer and moose with severe infestations of this tick may die. The loss of flesh in individuals that survive, though not so readily demonstrated, must be considerable. Controversy has existed between Fenstermacher (1934) and Wallace, Cahn, and Thomas (1933) over the nature of such conditions. The cause of death by ticks in domestic rabbits and possibly wildlife by an exsanguination anaemia is discussed by Jellison and Kohls (1938). A similar condition of anaemia has been observed at Kamloops during the infesting of white mice with *D. andersoni* adults (Gregson, 1952). Toxicity from the feeding of ticks may also account for certain effects in host animals, for it is known that some species contain powerful irritants within their systems (Mlinac and Oswald, 1936, 1937; Steinhaus, 1942; Gregson, 1941a, 1942d).

Depreciation due to ticks must surely also arise in deer from heavy infestations by the ear tick, *Otobius megnini* (Gregson, 1953). If the ticks cause deafness in such animals they would likewise constitute an adverse factor in conservation because of increased toll by predators.

Losses in big game caused by *D. andersoni* are not comparable to those in livestock; the only record of an outbreak of tick paralysis in wildlife is that of buffalo reported by Kohls and Kramis (1952).

Game birds and rabbits are also affected by ticks. Both are hosts of the two species of *Haemaphysalis* in Canada, and, since these ticks may be natural vectors of tularaemia, it is believed by some (Brown, 1944a) that they play a part in the periodic fluctuations of such game.

Because of the complexity of the balance of nature and the great variety of hosts of the various species of ticks in Canada there is reason to assume that these parasites play an important and little-understood role in the over-all picture of animal populations.

DISTRIBUTIONS AND HOST RELATIONSHIPS

Ticks, in general, are found in largest numbers, both of species and of individuals, in temperate and tropical regions. Canada lies in the northern portion of their distribution and no species occur there that are not also found south of the Canadian-United States border. Their northward distribution is limited and few species are taken above the 54 parallel.

Of the two families, the Argasidae, or soft ticks, are the less tolerant of Canadian climatic conditions, the few species of this group recorded in Canada being either transients from the south or confined to the warmer, southwest portion of the country. The remaining group, the Ixodidae, or hard ticks, include the bulk of the northern species; and although the temperate southern coast of British Columbia supports the largest portion of them, representatives of *Haemaphysalis, Dermacentor,* and *Ixodes* are found across southern Canada, some species occurring in the northlands.

The fact that about three-quarters of the species of ticks recorded in Canada occur in British Columbia is explained in part by the mild and diverse climates of portions of this province and its longitudinal mountain barriers permitting a singularly high species content, both of flora and of fauna. As a result there occur in the humid and southern Pacific coast areas such moisture-loving species as *Ixodes pacificus, I. auritulus,* and *I. soricis,* all probably restricted by the climate since apparently suitable hosts of all stages of these ticks occur in the neighbouring dry interior of the province. Conversely, *Dermacentor andersoni* appears unable to tolerate the coastal moisture as it does not normally occur west of the Coast Mountains. That it does occur in the equally wet portions of the interior wet belt along the Columbia River may be because much of the precipitation there occurs as snow.

Since *Ornithodoros* ticks favor dry, hot to temperate climates, it would be expected that the warm interior of British Columbia, particularly the Okanagan Valley, would yield the first records of both *O. hermsi* and *O. parkeri* in their natural habitats. The Canadian records of *hermsi* are, so far, all from occupied human dwellings, so that, even if established as breeding colonies, the ticks concerned cannot be considered to be truly indigenous and capable of surviving the rigors of Canada's climate. Similarly, ticks from birds or from their nests must be regarded as recent transients from the south unless it is proved that they have over-wintered in Canada.

Other species of ticks, such as *Haemaphysalis leporis-palustris, Dermacentor albipictus,* and *Ixodes angustus,* are found through a range of Canadian climates and have been recorded from most of the provinces.

Host relationships play an important part in the distribution of those ticks that are either host-specific or dependent on a small group of hosts. Examples are *Ixodes ochotonae,* which with few exceptions feeds on the pika (*Ochotona* sp.); *I. marmotae,* which feeds on western groundhogs *(Marmota flaviventris);* and *I. signatus* and *I. uriae,* both of which appear to be confined, with rare exceptions, to marine birds. The last ticks, possibly because of the temperate environment of their hosts, have a remarkably wide coastal distribution. Unless host-subspecificity is a factor, other ticks appear to have their distribution restricted by other factors, probably the climate. For instance, *I. hearlei* is rarely found east or west of the interior dry zones of British Columbia, even though squirrels *(Tamiasciurus hudsonicus),* though of different subspecies, are widely distributed in Canada. Conversely, *I. soricis* is confined mainly to the wet Pacific coastal belt although most of the species of shrew *(Sorex)* on which it occurs are represented elsewhere in Canada by subspecies. With the exception of the occasional migrant, the same may be said of the coastal bird tick, *I. auritulus.* Some closely allied ticks are parasites of similar hosts but their ranges are separated by continental plains that no doubt have aided their divergence and certainly at present assist in their separation by the taxonomist. Among these may be listed the squirrel ticks, *I. hearlei* and *I. marxi,* and the carnivore ticks, *I. rugosus* and *I. cookei.* Other species of ticks appear to be restricted to certain regions for no apparent reason. For example, *I. kingi* and *I. sculptus* are virtually restricted to the prairie region on ground squirrels and some of their predators, although the same or allied hosts are available in British Columbia. Neither is host-specific and both occur commonly west of the Rocky Mountains in the United States. Similar unexplained conditions exist among certain fleas and their hosts (Holland, 1949).

Even more striking is the dividing line between *Dermacentor andersoni* and *D. variabilis* in Canada. Both these ticks are rather tolerant of climatic conditions and they have similar life-cycles and a variety of hosts. Yet *andersoni* and *variabilis* are not known to occur naturally east and west, respectively, of a line running south through central Saskatchewan. Although there is a certain amount of overlapping of the two species in the United States, this line continues south near the eastern borders of Montana, Wyoming, Colorado, and New Mexico. It is possible that still less evident limitations of distribution within species of ticks may occur. In considering the role played by *D. andersoni* in the production of tick paralysis it has been shown by Jellison and Gregson (1950) that, although this tick is found both east and west of the Rocky Mountains, tick paralysis seldom occurs east of the divide. Correspondingly, in British Columbia at least, this species of tick is less frequently a carrier of Rocky Mountain spotted fever on the western side of the mountains. Could it be that the ticks from these two regions represent separate physiological races or sibling species?

Tick distribution within an area is further controlled by microclimatic and local host conditions. This is particularly apparent in such species as *D. andersoni* and *I. pacificus,* which in their adult stages may be readily detected on vegetation. When one is collecting these species, sites within a tick zone that outwardly appear ideal for tick habitation often prove to be tick-free. It is suspected that in such local instances proper humidity is basically the main criterion for tick establishment. This may be necessary not only for the survival of the tick but also for that of its hosts and their food.

The movement of the host may determine the shifting, local habitat of the one-host tick *D. albipictus,* for the location of its hosts (deer, moose, and horses) in the spring determines where the engorged females drop off and the succeeding generation develops. It is possible that tick survival may also be determined by a physiological relation between host and parasite. Field and laboratory observations suggest that animals in good condition are not so susceptible to parasitism as those that are undernourished. This may explain why, at the Kamloops laboratory, considerable difficulty has been experienced in infesting pastured horses with larvae of *D. albipictus* freshly taken from the neighbouring hills, and why *albipictus,* even though conveyed from rangeland to valley farms by the winter movement of infested horses, rarely becomes established on the healthier animals at the lower altitudes.

Host immunity is probably another factor governing the survival of ticks. It has been observed (Trager, 1939 and 1940; Gregson, 1942c) that resistance against certain ticks may be built up during laboratory infestations. In heavy natural infestations of ticks this immunity might serve to curb their increase. A somewhat kindred effect of host on parasite has been noted at the Kamloops laboratory, where it has been shown from field collections of *D. andersoni* that adults that have fed on ground squirrels (*Citellus c. columbianus*) in the nymphal stage are noticeably smaller than those that have fed on wood rats *(Neotoma occidentalis).*

In summary, it will be apparent from these remarks that our knowledge of some of the parasite-host-climate relationships is exceedingly scanty, and that much remains to be done before a number of problems can be thoroughly understood.

NOTES ON LIFE HISTORIES

Of the 28 species recorded in Canada, six are almost entirely specific to certain animals during the various stages. The remainder either tolerate hosts of related species or, like *D. andersoni,* feed on any of a wide range of animals during each instar. Except *D. albipictus* and *O. megnini,* which, after hatching and reaching a host, remain on the animal, all species must have a new host for each instar.

The hosts may be small animals for all active stages, or may include ungulates or man for the final feeding. Not only mammals but also birds, and even reptiles, may be parasitized, depending on the species. Because of these differences, it is difficult to cite a life-cycle typical of ticks. However, most species of the family Ixodidae adhere to the following pattern. A replete female dropped from her host seeks refuge under debris on the ground. In a month or more she lays several thousand eggs and dies. From the eggs emerge active, six-legged larvae, or "seeds", which rest among or climb up on low vegetation, in wait for a suitable host. When one is attained, they attach to its skin and slowly engorge. In about three days they drop to the ground, where after a quiescent period of several weeks they moult into nymphs, which are eight-legged. The nymphs seek a new animal, and, after obtaining a blood meal, again drop to the ground and moult. The resulting, final stage is sexually mature and may mate before or during feeding, depending on the species. In some species, the males never feed; in those that do, they take only a small amount of blood, and because of their structure are unable to distend appreciably. Although the adults of *D. andersoni, D. variabilis,* and *I. pacificus* wait for their hosts in conspicuous positions, at the ends of grasses and low shrubs, the unfed adults of most species are rarely seen, and presumably remain close to the nests or runways of their hosts. Once upon their hosts, the female ticks attach themselves for about one week. During this interval, as the tick engorges, it slowly distends to several times its original size and assumes a

beanlike appearance. Although different species of unfed ticks vary considerably in color, the fully fed females are usually blue-gray. When fed, the female tick is obliged to proceed to its next role of activity, although temporary dormancy may be induced by cold weather. Unfed, many species are extraordinarily hardy and can survive several years of starvation. The life-cycle of *I. texanus* has been shown to be theoretically capable of extending over 21 years (Gregson, 1949b). Other species, like *I. pacificus,* are so delicately adjusted to climatic factors that the adults appear to live for only a few months under the best of conditions. The life-cycles of the argasids are strikingly different. These may have a series of nymphal and adult feedings with corresponding moults and ovipositions. The larvae of *O. megnini* even pass into a quiescent, bladder-like stage before moulting into the nymph, and the adults do not feed. Although, as a rule, argasids are fast feeders and engorge during a few hours or less, nymphs of *O. megnini* remain attached and feeding for months.

Further notes on the life-histories are given in the discussion of the individual species.

TERMS AND METHODS USED IN CLASSIFICATION

The classification of ticks is difficult because closely related species are frequently very similar morphologically. Differences are often hard to detect, and consist of slight ridges, pores, or depressions that must be viewed vertically; spines, spurs, and humps that lack demarcation from their points of origin; or the dentition of hypostomes, which are often missing. For each character the differences are usually relative, difficult to illustrate, and still harder to describe. In many instances the separation of similar species of ticks can be assisted by a study of their sexes, other stages, their hosts, or their distributions. A few Canadian examples are *Otobius megnini* and *O. lagophilus,* the nymphs of which have widely different cuticles and hosts; *Ixodes angustus* and *I. ochotonae,* the nymphs of which differ in palpal structure; *Ixodes soricis,* which is host-specific, as opposed to *I. angustus,* and which, like *I. kingi,* becomes distinctly spherical when engorged. The unusually long coxal spine on males of *Haemaphysalis chordeilis* readily separates them from males of *H. leporispalustris,* although the females of the two species are closely alike. *Ixodes cookei* and *I. marmotae,* similar morphologically, occur east and west of the central plains respectively; consequently locality data assist in their identification.

Because of these taxonomic difficulties, special attention must be paid to all factors that may contribute to the identification of species. It is therefore important that all available data on host and locality accompany specimens. In removing the tick from its host, care should be taken to retain its mouth parts. It is then best preserved in 70 per cent alcohol. This medium is recommended for permanent storage (rather than mounts on slides) since structures are best seen by reflected light and occasionally must be viewed at different angles to appreciate their various values. If necessary, the specimen may be blotted and examined out of the alcohol, care being taken that it does not dry out. Finally, when a microscopic examination is made, as powerful a source of light as possible should illuminate the specimen. If the tick is dirty, a fine brush may be used to clean the structures. Some portions may have to be exposed by the movement of a leg or palpus or placed in a level position by elevating one side or end of the tick.

To facilitate the identification of specimens, careful consideration has been given to the selection of suitable characters for use in the keys. As the hypostome is often missing or damaged, and in any case is hard to see, reference

to this structure is omitted where possible. Similarly, a minimum of attention is directed to structures that are either variable or difficult to evaluate. These include cervical and lateral grooves, carinae, punctuations, and capitular margins and cornua. This elimination of a number of characters used by Cooley and Kohls (1945) in their keys to the North American species of *Ixodes* has been made possible by the restricted tick fauna in Canada.

Considerable stress has been placed on such clearly discernible structures as coxal spurs and nymphal palpal horns, and although the differences in these between species are still relative they are at least easy to illustrate.

The illustrations accompanying the following keys are from *camera lucida* drawings of actual specimens. Though not necessarily drawn to the same scale, they are intended to illustrate relative differences in structure and outline.

Definitions of Terms Used in Text

(See Plate II also.)

For more detailed definitions see Cooley (1938, and 1946a), Cooley and Kohls (1944a, 1945), and Nuttall *et al.* (1911).

Accessory shields: Paired shields outside the adanal shields in males of *Rhipicephalus.*

Adanal plates: Paired ventral plates bordering the anal plate in males of *Ixodes.*

Adanal shields: Paired ventral shields near the anus in males of *Rhipicephalus.*

Anal groove: The groove that partially encloses the anus (anteriorly in *Ixodes,* posteriorly in *Dermacentor*).

Anal plate: The single median plate surrounding the anus in males of *Ixodes.*

Anterior spur: An anterior, inwardly directed projection on article I of the palpi of certain species of *Ixodes* (see *auritulus* female, or *angustus* and *sculptus* nymphs).

Anus: The posterior opening of the alimentary tract, situated ventrally and caudally on the median line. It consists of two movable valves surrounded by a sclerotized ring.

Article: A distinct division of a jointed appendage.

Auriculae: Paired ventral extensions at the sides of the basis capituli of some species of *Ixodes.* They may be strong, retrograde, and hornlike; flattened ridges; or mild protuberances.

Basis capituli (or basis): The basal portion of the capitulum.

Camerostome: The depression or cavity in which the capitulum of the Argasidae lies.

Capitulum: The anterior portion of a tick, including the basis capituli, palpi, hypostome, and chelicerae.

Cervical grooves: The pair of grooves in the scutum that are directed posteriorly from behind the cornua. They are present in all stages and in both sexes of the Ixodidae.

Chelicerae: Paired mouth parts lying dorsally on the hypostome and used for piercing the host's skin by their independent backward and forward motion. Each terminates in an internal and external serrated "digit".

Cornua: Caudad projections extending from the latero-posterodorsal angles of the basis capituli of ixodid ticks.

Corona: The apical portion of the hypostome, usually armed with numerous small denticles.

Coxae: The paired ventral plates to which the legs are movably attached. Beginning anteriorly, they are designated as I, II, III, and IV.

Coxal spurs: Large or small, long or short projections on the posterior margins of the coxae of ixodid ticks. In *Ixodes* the outer and inner are known as the external and internal spurs.

Crenulations: The transverse or diagonal rows of mild denticles found on some male hypostomes.

Denticles: The recurved "teeth" on the ventral side of the hypostome. These are usually arranged in parallel longitudinal rows, or files.

Dentition: The arrangement or number of files of teeth found on each side of the median line of the hypostome, for example, 2/2 or 3/3. The outermost row is designated as file 1.

Dorsal pits: The pits or depressions on the dorsum of *Otobius* adults.

Dorsal humps: Humps or elevations on the dorsal walls of the articles of the legs of certain argasids, but not including the dorsal protuberance.

Dorsal prolongation: The posterodorsal extension of the spiracular plate, as in *Dermacentor andersoni.*

Dorsal protuberances: The dorsal subapical humps present on the legs of certain argasids.

Dorsal ridge: The posterior transverse ridge between the cornua of ixodid ticks.

Dorsum: The upper surface of the body, in contradistinction to the venter.

Emargination: The excavation between the scapulae of Ixodidae in which the basis capituli is seated.

Epimeral plates: Paired lateroventral plates enclosing the spiracles of *Ixodes.*

External spur: See *coxal spurs.*

Eyes: A pair of lenslike structures at the sides of the scuta of certain genera of ixodids, and two pairs along the submargins of certain argasids.

Festoons: Uniform, more or less rectangular areas separated by grooves, along the posterior submarginal area of the dorsum in both sexes of *Dermacentor, Rhipicephalus,* and *Haemaphysalis* spp.

Files: See *denticles* and *dentition.*

Genital aperture: The sexual opening of adult ticks, situated on a median line between the coxae.

Genital grooves: Long ventral grooves diverging from each side of the genital aperture and extending close to the posterior margin of the body.

Goblets: The numerous pores surrounding the macula in the spiracular plate of ixodid ticks.

Granulations: Pebbled elevations on the integument of *Otobius* spp.

Hood: The anterior projection of the integument of certain Argasidae.

Hypostome: The median ventral toothed mouth part that is immovably attached to the basis capituli.

Internal spur: See *coxal spurs.*

Lateral carinae: Faint or strong ridges along the sides of the scutum and continuous with the lateral grooves of *Ixodes* species.

Lateral grooves: The dorsal grooves at the sides of the scutum in male ixodid ticks.

Legs: Designated as I, II, III, and IV in anterior to posterior sequence.

Macula: The heavily sclerotized central portion of the spiracular plate of adult Ixodidae.

Mammillae: Rounded elevations found on the integument of *Ornithodoros* spp.

Marginal grooves. The dorsal grooves posterior to the scutum at the sides of the body in female ixodid ticks.

Marginal body folds: The folds outside of the marginal (female) or lateral (male) grooves of both sexes and all stages of ixodids.

Median plate: The median ventral plate of males of *Ixodes,* situated between the genital and anal apertures.

Ornamentation: The pattern of gray superimposed over the brown integument in *Dermacentor* spp.

Palpi: The movable paired appendages, parallel, and on each side of the hypostome. Each consists of four articles, numbered from the base, although the first may may be obsolescent or absent, as in *Haemaphysalis* spp.

Panduriform: Obovate, with lateral concavities, like a violin.

Porose areas: Paired, pitted areas, usually depressed, on the dorsoposterior of the basis capituli of females of the Ixodidae. Absent in males, nymphs, and larvae.

Pregenital plate: The ventral plate, anterior to the genital aperture, in some male ixodids.

Punctations: Pits in the surface of the scutum and other parts of the exoskeleton.

Salient: An edge that projects, in contradistinction to a rounded margin.

Scapulae: The anterior angles of the scutum in both sexes of ixodid ticks.

Scutum: The sclerotized plate covering all or most of the dorsum (excluding appendages)in males, and the anterior portion in females, nymphs, and larvae of the Ixodidae.

Spiracles (or spiracular plates): Paired respiratory pores, usually situated behind or lateral to coxa IV.

Sutural line: a definite line of cleavage about the periphery in *Argas* spp., separating the dorsal and ventral surfaces.

Tarsal hump: The terminal dorsal hump, present on the tarsi of certain species of *Ixodes.*

Tarsus: The terminal article of the leg.

Venter: The lower surface of the body, in contradistinction to the dorsum.

Ventral cornua: Retrograde horns on the posterior margin of the ventral surface of the basis, as in *Haemaphysalis leporis-palustris.*

Ventral plates: The ventral plates of males of *Ixodes.*

Key to Families and Genera

Since engorged nymphs may easily be mistaken for partially engorged females, it is important to determine the stage of the tick before using a key. A sexually mature tick is recognizable by the presence of the genital aperture, which is lacking in the larval and nymphal stages. The larvae are distinguished by having only three pairs of legs. The key should be used in conjunction with the illustrations (referred to by superscripts), which are designed to show differences between closely related or similar species. Full advantage should also be taken of host and distributional data when available.

1 Scutum present (covering entire dorsum of male and anterior portion of female); capitulum terminal; integument smooth (Ixodidae) 4
Scutum absent; capitulum ventral; integument leathery and pebbled, or spiny (Argasidae) 2

2 (1) Dorsal and ventral surfaces separated by a definite sutural line[1] ..... *Argas*
Dorsal and ventral surfaces not separated by a definite sutural line 3

3 (2) Nymph with integument covered with spines;[15] adult with granular integument and with vestigial hypostome[13] ..... *Otobius*
Nymph and adult with mammillated integument; hypostome not vestigial in adult ..... *Ornithodoros*

4 (1) Festoons absent (if specimen is engorged, consider alternate also); anal groove anterior to anus[43] ..... *Ixodes*
Festoons present (though they may not be apparent in engorged specimens); anal groove posterior to anus[20] 5

5 (4) Ornate ticks; basis capituli and palps of adult together dorsally rectangular in outline[18] (basis capituli triangular in early stages of *D. variabilis* and *D. andersoni*)[23 24] ..... *Dermacentor*
Inornate ticks; basis capituli and palps together not dorsally rectangular in outline 6

6 (5) Eyes absent; palps conical, flaring at the base; basis capituli of adult dorsally rectangular; small ticks[25] ..... *Haemaphysalis*
Eyes present;[39] palps dome-shaped, but not flaring out at the base; basis capituli dorsally hexagonal; large ticks ..... *Rhipicephalus*

Key to Species

Genus *Argas*

Margins of body striate and flattened; post-palpal hairs absent; hypostome rounded apically. Recorded from bluebird's nest, southern British Columbia. Associated with wild birds in the United States, where it is rare. Common on pigeons in the Old World ..... *reflexus*, p. 24

Margins of body of quadrangular plates;[2] post-palpal hairs present;[4] hypostome notched apically. Recorded from sparrow, southern British Columbia. The common fowl tick of the southern United States and the Old World ..... *persicus*, p. 24

Genus *Ornithodoros*

Only one species recorded to date, from bird and mammal nests in human dwellings in southern British Columbia. Present at the higher elevations of the western United States ..... *hermsi*, p. 25

Genus *Otobius*

Dorsal pits of adult two or more times their diameters apart;[14] integumental spines of nymph heavier in anterior portion of body;[15] legs stout; body panduriform; hypostome denticles 4/4. From ears of deer and mountain sheep in southern interior of British Columbia, and Rocky Mountains. Common in ears of domestic animals in the southern United States ..... *megnini*, p. 26

Dorsal pits of adult one or less times their diameters apart;[16] integumental spines of nymphs similar all over body;[17] legs moderate; body less panduriform than in *megnini;* hypostome denticles 3/3. From cottontail and jack rabbits from southern Alberta and the northwestern United States ..... *lagophilus*, p. 27

Genus *Dermacentor*

1 Spiracular plates of adult with dorsal prolongations and with goblets in large or moderate numbers. Nymphs with basis capituli drawn laterally to sharp points;[23] body not noticeably elongate. Adults on large hosts; nymphs usually on rodents 2

Spiracular plates of adult without dorsal prolongations and with goblets few and large. Basis capituli of nymph not drawn laterally to sharp points; body noticeably elongate. A one-host tick of moose, deer, cattle, and horses. Found in greater portion of Canada and the United States ..... *albipictus,* p. 31

2 (1) Spiracular plates of adult with goblets very numerous and small[23] Coxa IV of nympth with no external spur. Adults common parasites of dogs, man, cattle, horses, and large wildlife; early stages on rodents and rabbits. Found from Saskatchewan east, and in east-central and western United States ..... *variabilis,* p. 30

Spiracular plates of adult with goblets moderate in size and number.[24] Coxa IV of nymph with faint external spur; posterior margin of basis capituli in three arcs. Adults found on man, cattle, dogs, sheep, horses, and large wildlife; early stages on rodents and rabbits. Found from central Saskatchewan west and in the western United States *andersoni* p. 28

Genus *Haemaphysalis*

Posterior margin of palpal article 2 noticeably reflexed;[23] hypostome dentition 3/3; ventral cornua strong and rounded; internal spur of coxa IV of both sexes small; basis capituli of nymph and larva quadrangular dorsally. Common on cottontail and jack rabbits throughout their range in Canada and the United States..... *leporis-palustris,* p. 34

Posterior margin of palpal article 2 only slightly reflexed;[32] hypostome dentition 5/5; auriculae mild and nearly absent; internal spur of coxa IV prominent, that of the male being long and pointed; basis capituli of nymph and larva hexagonal dorsally.[35] Found on various ground birds and occasionally on mammals, including man. Distributed widely in Canada and the United States ..... *chordeilis,* p. 35

Genus *Rhipicephalus*

Only one species recorded for North America. Spreading in Eastern Canada, and now present in greater part of the United States. Common on dogs, occasionally bites man ..... *sanguineus,* p. 33

Genus *Ixodes*

FEMALES

1 Coxa I with no spurs;[57] body very hairy.[56] Found on sea birds along Pacific and Atlantic coasts ..... *uriae,* p. 45

Coxa I with spurs present; body not noticeably hairy 2

2 (1) Coxa I with internal spur about equal in length or less (not extending over coxa II in unfed specimens—maximum size in *angustus*[103]) than external spur; scutal dimensions variable 3

Coxa I with internal spur robust and considerably longer (extending over coxa II in unfed specimens) than external spur; scutum about as broad as long 10

3 (2) Auriculae present as stout horns or broadly rounded extensions 4

Auriculae as only mild spurs or absent 5

4 (3) Coxa I without internal spur;[66] scutum longer than broad;[65] auriculae as rounded extensions;[67] palpal article I without anterior projection. Found on sea birds; also recorded from seal and rosy finch. Distribution: Pacific coast, Aleutians, and Japan ..... *signatus,* p. 45

Coxa I with internal spur present; scutum as broad as long; auriculae as heavy horns; palpal article I with anterior projection.[141] Recorded from birds along the Pacific slope from Queen Charlotte Islands to South America. In British Columbia rarely found east of the Coast Mountains ..... *auritulus,* p. 41

5 (3) Scutum as broad as long 6

Scutum longer than broad 7

6 (5) Shoulders of hypostome humped.[76] A widely distributed parasite of mustelids, recorded from British Columbia, southern Ontario, and the greater portion of the United States ..... *texanus*, p. 40

Shoulders of hypostome sloping evenly. Found on tree squirrels in central and eastern British Columbia. Occasional records from the western United States ..... *hearlei*, p. 41

7 (5) Exceptionally small tick (unfed ♀, 1·5 mm. x 0·5 mm.); longitudinal wrinkles in posterior portion of scutum.[120] Spherical when engorged.[123] Taken only from shrews west of the Coast Mountains in British Columbia, and as far east as Colorado in the United States ..... *soricis*, p. 39

Medium-sized ticks without longitudinal wrinkles in posterior portion of scutum. Not spherical when engorged 8

8 (7) Auriculae present as rounded humps.[94] Found on tree squirrels in Eastern Canada and the United States ..... *marxi*, p. 42

Auriculae absent 9

9 (8) Files three seldom more than about half total length of hypostome;[114] palpal article I of nymph without anterior projection.[119] A common parasite of pikas in southeastern British Columbia. Also recorded from wood rat and vole ..... *ochotonae*, p. 39

Files three more than half total length of hypostome;[105] palpal article of nymphs with anterior projection.[110] Found on tree squirrels, mice, and other rodents in Western, Northern, and Eastern Canada, and in the western and northeastern United States ..... *angustus*, p. 38

10 (2) Auriculae present; scutum longer than broad 11

Auriculae absent; scutum about as broad as long 12

11 (10) Auriculae curved, pointed, and hornlike.[131] Found on wood rats, hares, pikas, squirrels, mice, and shrews in southern British Columbia and the northwestern United States ..... *spinipalpis*, p. 37

Auriculae straight, blunt, and spurlike.[149] Found on mice, and occasionally small birds, in Eastern Canada and the northern United States ..... *muris*, p. 45

12 (10) Scutum circular;[46] legs and capitulum dark. Commonly found on deer, man, cats, and dogs west of the Coast Mountains from southern British Columbia to California in the United States ..... *pacificus*, p. 36

Scutum angular; legs and capitulum not dark 13

13 (12) Internal spur of coxa I long, with pointed end 14

Internal spur of coxa I long, with rounded end 15

14 (13) Shoulders of hypostome flattened;[188] scutum with large punctations and wrinkles on anterolateral area of scutum. Found on skunks and dogs west of the Coast Mountains from southern British Columbia to California in the United States ..... *rugosus*, p. 40

Shoulders of hypostome sloping;[167] scutum with punctations, but not wrinkled as in *rugosus*. Found on skunks, raccoons, dogs, and marmots in Eastern Canada and the eastern United States ..... *cookei*, *p. 44

15 (13) Hypostome noticeably stout, with conical teeth;[199] engorged female spherical.[198] A parasite of ground squirrels, weasels, and occasionally dogs. Distribution: southern Alberta and the central United States ..... *kingi*, p. 43

Hypostome normal, teeth curved 16

16 (15) Posterior margin of basis capituli sinuous.[156] Commonly found on ground squirrels in southern Alberta and the central and western United States ..... *sculptus*, p. 43

Posterior margin of basis capituli straight. Found on marmots and ground squirrels in the interior of British Columbia and in the northwestern United States ..... *marmotae*, p. 42

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*Since going to press, G. M. Kohls has kindly drawn to my attention the fact that two collections referred to as of *I. cookei* have since been identified as of *I. banksi*, making a new record for Canada. Females of this species key out to *I. cookei* here, but may be distinguished from the latter by their relatively large spiracles. It has been found on muskrats and beaver in Eastern Canada and the eastern and southern United States. See p. 46.

MALES

Unless otherwise indicated, hosts and distribution are the same as listed in the key to the respective females.

1 Palpal article 4 arising back from end of article 3; [60 69] dentition of hypostome faint or absent 2
Palpal article 4 arising from near end of article 3; dentition of hypostome present 3

2 (1) Body with terminal fringe of spines;[59] coxa I with no spurs. Probably non-feeding, and found only in nests of hosts ..... *uriae*, p. 45
Body without terminal fringe of spines; coxa I with external spur only.[72] Probably non-feeding, and found only in nests of hosts ..... *signatus*, p. 45

3 (1) Hypostome with conspicuous lateral denticles that are well differentiated from the small diagonal or transverse rows of median denticles[50] 4
Hypostome with lateral denticles not well differentiated from median denticles[160] 5

4 (3) Spiracular plate oval;[52] internal spur of coxa I usually sharp; [51] auriculae as slight ridges ..... *pacificus*, p. 36
Spiracular plate circular;[134] internal spur of coxa I usually blunt; auriculae as obtuse projections ..... *spinipalpis*, p. 37

5 (3) Internal spur of coxa I long (overlapping coxa II) 6
Internal spur of coxa I moderately long or short (not overlapping coxa II) 7

6 (5) Median denticles of hypostome as diagonal crenulations;[160] marginal grooves more nearly straight than those of *rugosus* ..... *cookei*, p. 44
Median denticles of hypostome as lineal files;[190] marginal grooves convex ..... *rugosus*, p. 40

7 (5) Median plate longer than anal plate 8
Median and anal plates about equal in length 13

8 (7) Adanal plates of equal width at both ends [200] ..... *kingi*, p. 43
Adanal plates broader in front 9

9 (8) Hypostome notched at apex;[152] spiracular plate large ..... *muris*, p. 45
Hypostome rounded at apex; spiracular plate small 10

10 (9) Internal spur of coxa I small; external spur absent[143] ..... *auritulus*, p. 41
Internal spur of coxa I prominent; external spur present 11

11 (10) Internal spur of coxa I longer than external spur;[161] ventral plates with distinct punctations; lateral sides of adanal plates not parallel *sculptus*, p. 43
Internal spur of coxa I about equal in length to external spur; ventral plates without distinct punctations; lateral sides of adanal plates nearly parallel 12

12 (11) Very small tick, length of male about 0·1 mm. ..... *soricis*, p. 39
Medium-sized tick, length of male about 1·5 mm. ..... *angustus*, p. 38

13 (7) Punctations less distinct on median than on anal and adanal plates 14
Punctations about equally distinct on all ventral plates 15

14 (13) Spiracular plate large, with many goblets[78] ..... *texanus*, p. 40
Spiracular plate small, with few goblets[96] 16

15 (13) Median plate nearly as broad as long[115] ..... *ochotonae*, p. 39
Median plate longer than broad[180] ..... *marmotae*, p. 42

16 (14) Venter of basis capituli with transverse wrinkles[97] ..... *marxi*, p. 42
Venter without transverse wrinkles ..... *hearlei*, p. 41

NYMPHS

(Differences in the larvae are less apparent, but as a rule this key suggests the species concerned.)

Unless otherwise indicated, hosts and distribution are the same as listed in the key to the respective females.

1 External spurs vestigial or absent on all coxae 2
External spurs present on coxa I 5

2 (1) Scutum widest at anterior end[62] ..... *uriae*, p. 45
Scutum widest near middle 3

3 (2) Shoulders of hypostome humped[82] ..... *texanus*, p. 40
Shoulders of hypostome not humped 4

4 (3) Scutum about as wide as long; auriculae arising anterior to middle of basis capituli[91] ..... *hearlei*, p. 41
Scutum slightly longer than wide; auriculae arising posterior to middle of basis capituli[101] ..... *marxi*, p. 42

5 (1) Internal spurs of coxa I absent[72] ..... *signatus*, p. 45
Internal spurs of coxa I present 6

6 (5) Auriculae absent (or, at the most, shelf-like extensions) 7
Auriculae present (as triangular or curved projections) 15

7 (6) Scutum nearly circular;[53] ventral plate of palpal article I not conspicuous, and its horns absent. Found on lizards, small mammals, and birds ..... *pacificus*, p. 36
Scutum not nearly circular; ventral plate of palpal article I conspicuous, with either or both anterior and posterior horns present 8

8 (7) Anterior horn of palpal article I small or absent[119] 13
Anterior horn of palpal article I present;[110] posterior horn may or may not be present 9

9 (8) Internal spur of coxa I considerably longer than external spur 10
Internal spur of coxa I rounded and equal in size to external spur 12

10 (9) Scutum conspicuously wider than long;[172] posterior horn of palpal article I indistinct; internal spur of coxa I long and tapering[173] ..... *cookei*, *p. 44
Scutum about as long as wide; posterior horn of palpal article I present; internal spur of coxa I ending bluntly 11

11 (10) Cornua long and prominent;[162] scutum widest near middle ..... *sculptus*, p. 43
Cornua moderate; scutum widest near anterior end ..... *marmotae*, p. 42

12 (9) Scutum with lateral carinae present; medium-sized ticks ..... *angustus*, p. 38
Scutum with lateral carinae absent; very small ticks ..... *soricis*, p. 39

13 (8) Posterior horn of ventral plate of palpal article I rounded and not directed backwards[194] ..... *rugosus*, p. 40
Posterior horn of ventral plate of palpal article I tapering and directed backwards 14

14 (13) Auriculae as distinct lateral extensions[204] ..... *kingi*, p. 43
Auriculae faint[119] ..... *ochotonae*, p. 39

15 (6) Palpi long and slender; internal spur of coxa I longer than external; plate of palpal article I without anterior horn; medium-sized ticks 16
Palpi short and broad; external spur of coxa I longer than internal; plate of palpal article I with anterior horn;[146] large ticks ..... *auritulus*, p. 41

16 (15) Scutum with lateral carinae; outer margin of palps concave[136] *spinipalpis*, p. 37
Scutum without lateral carinae; outer margin of palps straight[153] *muris*, p. 45

Family Argasidae Canestrini, 1890

Ticks without a scutum. Integument leathery and rough. Sexes similar in appearance. Capitulum and mouth parts of nymphs and adults situated below and behind the anterior margin of the body. These ticks often live for several years and usually lay comparatively few eggs following feeding periods at varying intervals. Most species feed rapidly and are nocturnal in habit. There may be more than one nymphal stage.

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*Nymphs of *I. banksi* also key out here. They may be distinguished from *I. cookei* by their relatively large spiracles. See p. 46.

Genus *Argas* Latreille

Genotype: *Acarus reflexus* Fabricius, 1794
Argas Latreille, 1796. Nuttall *et al.*, 1908, pp. 4-8. Oudemans, 1929, pp. 135-137, and 1936, pp. 746-755.

Body oval and flattened; dorsal and ventral surfaces about equal in area and separated by a flattened marginal rim that is not obliterated even when the tick is fully fed. Only two species are known to occur in North America. Both are considered to have been introduced from the Old World, and, with *Rhipicephalus sanguineus,* are the only ticks of Canada not indigenous to the Americas. Each of these argasids has been recorded from British Columbia.

ARGAS REFLEXUS (Fabricius)

Figs. 5, 6, 7, 8; Map I
Acarus reflexus Fabricius, 1794, pp. 426-427.
Argas reflexus, Latreille, 1802, p. 66.
Argas reflexus, Nuttall *et al.,* 1908, pp. 22-25.
Argas reflexus, Cooley and Kohls, 1944a, pp. 14-16.

Known as the pigeon tick because of its association with these birds in the Old World, this species has been taken only from nests of wild birds in North America. Of these, cliff swallows appear to be the predominating host.

Cooley and Kohls (1944a) listed only three records from California and one from Montana, but Kohls (in litt.) has records from several localities in Washington from nests of cliff swallows (*Petrochelidon pyrrhonata*). In Canada, specimens were taken with *Ornithodoros hermsi* from a bluebird's (*Sialia* sp.) nest at Summerland, B.C. This species is distinguished from *A. persicus* by the striated body margins, by the terminally rounded hypostome and by an absence of post-palpal hairs. The body margin of unfed specimens is slightly turned up, hence the name *reflexus.*

Canadian records

B. C. Summerland, 16.VII.49, ex *Sialia* sp. nest, 2♀, 3N (skins) (T.K.B.)

ARGAS PERSICUS (Oken)

Figs. 1, 2, 3, 4; Plate I, fig. 6; Map I
Rhynchoprion persicum Oken, 1818, p. 1568.
Argas persicus Fischer de Waldheim, 1823, p. 282.
Argas persicus (Oken), Nuttall *et al.,* 1908, p. 9.
Argas persicus, Hearle, 1938, p. 348.
Argas persicus, Cooley and Kohls, 1944a, pp. 17-20.

This species is believed to have been introduced from the Old World by man. It has become established firmly across the southern portion of the United States. Its continued spread to the more temperate zones suggests that it has considerable adaptability. However, apart from the single record from British Columbia, it has never been taken north of California, and it is doubtful if its occurrence in Canada would ever be more than transitory.

Primarily a fowl tick, this parasite has been taken from a variety of wild birds in the United States. The latter hosts probably aid in transporting the tick to new areas, though this must occur during the relatively long feeding period (5-10 days) of the larval stage. The subsequent stages gorge and drop from their hosts within a few hours. The adults may survive for as long as two years without a blood meal.

The sole record from Canada consists of four nymphs taken from a golden-crowned sparrow (*Zonotrichia coronata*) at Vancouver. Because of the short nymphal feeding period it seems that this infestation occurred from a previous introduction of larvae. The interval between these stages may be as short as eight days, according to Nuttall (1908, p. 81).

In its natural habitat this tick causes serious losses to fowl. Its bite on man may cause severe pain, shock, delirium, and even death.

Canadian records

B. C. Vancouver, 2.V.31, ex *Zonotrichia coronata,* 4N (R.A.C.)

Genus *Ornithodoros* Koch

Genotype: *Argas savignyi* Audouin, 1826
Ornithodoros, Koch, 1844, p. 219.
Ornithodoros, Nuttall *et al.*, 1908, pp. 39-40.
Ornithodoros, Cooley and Kohls, 1944a, p. 37.

Members of this genus are rounded in appearance and (except *O. dyeri* Cooley and Kohls) lack the marginal rim characteristic of *Argas* species. The adults differ from those of *Otobius* in having a well-developed hypostome; the nymphs, in lacking a spiny integument.

These ticks feed rapidly, and usually inhabit the resting places of their hosts, such as nests of birds or rodents, and bat retreats. Occasionally, when their habitat occurs in close association with human dwellings they move to attack man.

ORNITHODOROS HERMSI Wheeler, Herms, and Meyer

Figs. 9, 10, 11; Plate I, fig. 5; Map I

Ornithodoros hermsi Wheeler, Herms, and Meyer, 1935, pp. 1290-1292 (initial description).
Ornithodoros hermsi, Wheeler, 1935, pp. 435-438 (full description).
Ornithodoros hermsi, Cooley and Kohls, 1944a, pp. 46-49.

In Canada, *Ornithodoros hermsi* was first collected at Summerland, B.C. (Gregson, 1949a), in 1948, when a number of specimens were found in a bluebird's nest in an old woodpecker hole in the eaves of a house. Adult ticks had come from this nest and on several occasions had bitten a person who lived two storeys below. In 1949 another infestation was found in a similar habitat a mile away. Again the resident was bitten, but it is possible in this instance that the unseen tick might have been *Argas reflexus,* which was also found in the nest. Subsequently specimens have come to hand from persons bitten at Cultus Lake and Okanagan Landing, B.C. Although the origin of the last entries into homes could not be determined, it is suspected that bats, birds, or mice may have been involved. Although it would appear that this tick is rather widely distributed in British Columbia, examination of about a hundred nests of birds and rodents collected from trees and buildings revealed only one additional record. This consisted of a cast nymphal skin taken from bat and mouse droppings in a dwelling at Lac le Jeune, near Kamloops. Although Cooley and Kohls (1944a) considered chipmunks to be the true hosts on the basis of their experience in the United States, it seems probable that avian hosts play a more important part in the maintenance and distribution of this species in British Columbia. That such an argasid tick was present in British Columbia was suspected as early as 1934 (Hearle), when a vector was sought to explain a series of cases of relapsing fever in the Kootenay district. *O. hermsi* has been implicated with this disease in California, Colorado, Nevada, Oregon, Idaho, and Washington, though to date all Canadian specimens examined have been disease-free.

Data on the life-history of this species are sparse. Laboratory studies at Kamloops showed that the larvae and nymphs feed readily on mice, chipmunks, fowl, and bats. Although, as a rule, they engorge within half an hour, occasional specimens remain attached for several hours. Such instances of prolonged attachment must aid in the tick's spread to new localities by the travels of its hosts. The immature ticks moult after each feeding; there may be several moults during the nymphal stage. The adults feed several times, usually laying a few eggs after each meal. On occasion they may fast for as long as a year. As Nuttall *et al.* (1908, p. 84) observed with *Argas persicus,* the blood meal does not always appear to be agreeable, and not uncommonly engorged adults at the Kamloops laboratory turned purple and died. It is possible that some form of sensitization may be set up within the tick and that a change in hosts is necessary for its survival.

The bite of this tick on man is followed by a local reaction that may occasionally progress in the form of a severe though transitory shock. The site usually becomes a raised weal, which itches for weeks afterward. The close association of the hosts of this tick with human habitations, its longevity, and capacity as a disease carrier, together with its willingness to bite man, make it a species of considerable medical importance. The limited knowledge of its biology warrants its further study.

Canadian records

B.C. Summerland, 10.VII.48, ex man, 2♀ (C.M.)
Summerland, 10.VII.48, ex *Sialia* sp. nest, 26N (J.D.G.)
Cultus Lake, 6.VII.49, ex man, 1♀ (D.L.)
Summerland, 16.VII.49, ex *Sialia* sp. nest, 16N (skins) (T.K.B.)
Lac le Jeune, 28.VII.49, ex mouse nest, 1N (skin) (J.D.G.)
Okanagan Landing, 6.IX.50, ex man, 1♀ (J.D.G.)

Genus *Otobius* Banks

Figs. 12, 13
Genotype: *Argas megnini* Dugès, 1884
Otobius Banks, 1912, p. 99.

Body panduriform in shape. No change in integument at sides. Adults with granular integument; nymphs with numerous spines. Legs short and heavy. Capitulum distant from the anterior margin in adults, near the margin in nymphs. Hypostome vestigial in adults but well developed in nymphs.

OTOBIUS MEGNINI (Dugès)

Figs. 14, 15; Plate I, fig. 4; Map I
Argas megnini Dugès, 1884, pp. 197-198.
Ornithodoros megnini, Nuttall *et al.,* 1908, pp. 71-77.
Otobius megnini, Banks, 1912, p. 99.
Otobius megnini, Cooley and Kohls, 1944a, pp. 21-31.

This tick occurs commonly in the southern United States, where it is known as the spinose ear tick and is a serious pest of cattle and horses. Farther north, in the mountainous regions, deer and mountain sheep may be attacked. Other hosts include rabbits, dogs, coyotes, and man. In Canada this tick was first collected in 1941, when a specimen was taken from a cat at Ewings Landing, B.C. Specimens were next taken from the ears of mountain goat and sheep from Bryant Creek (near Windermere) and Vaseaux Lake (Okanagan Valley). In the fall of 1951, after the species was taken from deer at Barriere, B.C., a search was made in the ears of all available deer shot in the lower North Thompson valley. This indicated that the tick was present on about 60 per cent of the deer in this region, with infestations as high as 172 ticks per animal (Gregson, 1953).

There are no records from other provinces, Hearle's (1938) record of *Ornithodoros megnini* from Alberta being of *Otobius lagophilus.*

The life-history of this species is unique. It is solely an ear-inhabiting tick and the larvae and nymphs establish themselves deep in the ears of their hosts for periods of up to three months. These two stages are separated by a peculiar bladder-like resting stage. According to Nuttall *et al.* (1908, p. 104), when the fed nymphs drop from their host they "crawl up several feet from the ground and secrete themselves in cracks and crevices, where ... they shed a membranous skin and appear as adults without spines". Fertilization is followed by oviposition, after which the tick dies. Apparently the adults, which have only vestigal mouth parts, never feed. Though the early stages of this tick can be maintained in the ears of domestic rabbits, its long feeding period makes life-history studies very difficult. Unfed specimens have been known to live for two years.

Canadian records

B.C. Ewings Landing, 6.X.41, ex domestic cat, 1N (H.B.L.)
Bryant Creek, 19.VI.43, ex *Oreamnos americanus missoulae,* several N (I.McT.C.)
Barriere, 22.XI.50, ex *Odocoileus h. hemionus,* several N (I.McT.C.)
Vaseaux Lake, 2.II.50, ex *Ovis c. canadensis,* several N (I.McT.C.)
Jamieson Cr., -.XI.51, ex *Odocoileus h. hemionus,* many records (J.D.G.)

OTOBIUS LAGOPHILUS Cooley and Kohls

Figs. 16, 17; Map I

Otobius lagophilus Cooley and Kohls, 1940, pp. 928-933.
Ornithodoros megnini, Hadwen, 1913, p. 80, (*nec* Dugès, 1884).
Ornithodoros megnini, Hewitt, 1915, p. 225 (*nec* Dugès, 1884).
Ornithodoros megnini, Hearle, 1938, p. 349 (*nec* Dugès, 1884).
Otobius megnini, Brown, 1944, p. 49 (*nec* Dugès, 1884).
Otobius lagophilus, Brown, 1944, p. 49.
Otobius lagophilus, Cooley and Kohls, 1944a, pp. 32-36.
Otobius lagophilus, Brown and Kohls, 1950, pp. 201-202.

This species is distinguished from *megnini* in the adult stage by the closer proximity of the dorsal pits, which in *lagophilus* are not more than the distance of the diameter of a pit apart. The nymphs of *lagophilus* have spines of similar size, whereas in *megnini* the anterior spines are heavier in size. Denticles of the hypostome of the respective species are 4/4 and 3/3.

Although there is a single record from a cat, rabbits appear to be the true host of this tick. The nymphs attach themselves about the face of the host. The adults, like those of *megnini,* are not parasitic. This species is known only from the western United States and southern Alberta. It probably occurs also in southeastern British Columbia.

Canadian records

Alta. Lethbridge, -.X.12, ex *Lepus townsendii campanius,* 1N (S.H.)
Lethbridge, -.-.-, ex *Lepus townsendii campanius,* 3N (A.W.)
Lethbridge, 22.XII.31, ex *Lepus townsendii campanius,* 1N (H.S.)
Lethbridge, 12.XII.41, ex domestic cat, 1N (H.S.)

FAMILY IXODIDAE MURRAY, 1877

Ticks with a scutum, sexes different in appearance: the males almost entirely covered by the scutum and the females with a small scutum anteriorly. Capitulum terminal and conspicuous. These ticks may be short- or long-lived. The life-cycle includes three parasitic stages (larva, nymph, and adult), requiring as many separate blood meals. The females of all species engorge slowly and lay large numbers of eggs in one batch, after which they die. The

males feed sparingly or not at all. Nuttall *et al.* (1911) divide the family into two sections, the Prostriata, with anal grooves surrounding the anus in front (*Ixodes* spp.), and the Metastriata, with anal grooves contouring the anus behind (*Dermacentor, Haemaphysalis, Rhipicephalus,* and some genera not represented in Canada).

Genus *Dermacentor* Koch

Figs. 18, 19, 20, 21
Genotype: *Ixodes reticulatus* (Fabricius, 1794)
Dermacentor Koch 1844, p. 235.
Dermacentor, Nuttall and Warburton, 1911, p. 120.
Dermacentor, Cooley, 1938, pp. 15-16.

Ornate ticks with eyes and festoons. Anal groove posterior to anus. Basis capituli of adults rectangular (of nymphs, triangular or rectangular). Palpi short and broad or moderate in width. Coxae I to IV increasing in size progressively. Coxa I bifid. Males with no ventral plates.

DERMACENTOR ANDERSONI Stiles

Fig. 24; Plate I, figs. 1, 2; Map II
Dermacentor venustus Marx, 1892.
Dermacentor venustus Banks, 1908a, p. 46.
Dermacentor andersoni Stiles, 1908, p. 36.
Dermacentor modestus Banks, 1908b, pp. 170-171.
Dermacentor andersoni, Cooley, 1938, p. 31.
Dermacentor andersoni, Hearle, 1938, p. 353.
Dermacentor andersoni, Brown, 1944, p. 37.
Dermacentor andersoni, Brown and Kohls, 1950, p. 198.

Considerable discussion has arisen over the name of this tick. So involved are these controversial issues that they are summarized herewith.

Marx originally separated specimens of a tick from Texas from *D. occidentalis* Marx by labelling them *D. venustus* n. sp. Although this name was placed in vials with them, a description was never published.

Both *venustus* and *occidentalis* were considered by Neumann (1897) to be synonymous with *D. reticulatus* Fab. of Europe, the name *venustus* thereby having status as of 1897 (should the synonymy become invalid).

Banks, in 1908a (June 6), believing a series of ticks from "various places in the west", including Yakima, Wash.; Las Cruces, N. Mex.; Bozeman, Mont.; and Texas (Marx's specimens) all to be the same, described them (with no type locality) as *D. venustus,* in recognition of Dr. Marx's manuscript name.

Stiles, one month later (1908, July 3), believing the Montana species to be different from Marx's (Texas) *venustus,* described it as *D. andersoni,* a name that he had used in manuscript in 1905. At the same time he designated the Texas ticks as of *venustus.* Both were fully described by him in 1910.

Cockerell (1924) queried the validity of *venustus* as from 1897, asserting that the name was applied not as a substitute for *reticulatus* or any part of the genuine species but to the undescribed specimens of Marx, and though the valid name *D. venustus* would then date from Banks, 1908a, Stiles in 1910 was at liberty to restrict it to the material from Texas.

The critical issue was whether the Texas and Montana specimens were specifically different, for, as Stiles himself remarks, if they were identical the name *venustus* would necessarily be correct. In the meantime, the name *D. andersoni* was becoming accepted at such institutions as the Rocky Mountain Laboratory, Montana, and was in general usage in Western Canada.

Cooley (1938), in his treatise on the genera *Dermacentor* and *Otocentor,* states, "The writer has had the opportunity to examine the available types, and has found that *venustus* Marx, *venustus* Banks, and *andersoni* Stiles are all specimens of one and the same species. In retaining *andersoni* Stiles as the name of this important vector of diseases, instead of returning to *venustus* Banks, the writer has been influenced by the desire to avoid, as far as possible, further confusion in the literature of human and veterinary medicine and entomology".

At the present time it is understood from correspondence with Dr. C. B. Philip of the Rocky Mountain Laboratory, Hamilton, Montana, that the International Commission on Zoological Nomenclature has been petitioned to suppress the name *venustus* and officially accept that of *andersoni.* In anticipation of an affirmative decision, the present writer has continued to refer to this species as *andersoni.*

Specimens of *D. modestus* Banks, which was described after *venustus,* have been seen by Kohls and identified as *D. andersoni* (personal correspondence).

In North America the approved common name of this tick is the Rocky Mountain wood tick; in Canada it is also known as the paralysis tick, the spotted fever tick, and the spring or cattle tick as opposed to the winter tick, *D. albipictus,* which attacks horses, deer, and moose. Its distribution appears to be limited to regions extending from the Coast Mountains to the eastern Saskatchewan border and as far north as the 53rd parallel. Although it thrives in the interior wet belt, near Revelstoke, B.C., this tick does not appear to occur at the British Columbia coast. Two doubtful records from Harrison Bay and Hope suggest its possible presence west of the mountains.

In the interior of British Columbia the Rocky Mountain wood tick is found throughout the greater part of the dry bunch-grass open-land. Its abundance varies, depending on the locality, from sparse populations to heavy concentrations. The latter occur in scattered parts of the province where host and climatic conditions are apparently ideal for tick development and survival. Such areas are usually characterized by talus slopes backed by rocky bluffs, the feet of which usually provide a climate moist enough to support such vegetation as *Amelanchier* sp. (saskatoon), *Mahonia* sp. (oregon grape), *Agropyron* sp. (bunch grass), *Clematis ligusticifolia,* and a variety of flowers. This in turn provides cover and food for the rodents that are necessary for the survival of the early stages of the tick. In such areas hundreds of ticks may be collected in an hour. Holland (1940) mentions equally suitable habitats in the coulees of southern Alberta.

In British Columbia the season of adult activity usually lasts from the beginning of March to mid May, and reaches a peak in early April; east of the Rockies the active period may extend well into June. After these dates, adults that have not found hosts apparently enter a diapause by which (Gregson, 1951, p. 5), a small portion are capable of surviving until the following season. Philip (1953, p. 82) states that in confinement in nature unfed *D. andersoni* adults have survived into a third season.

During the active season the adult ticks wait on grass and twigs for a suitable host animal to pass. They have been taken from rabbits and marmots in nature and even feed readily on laboratory mice, but, as a rule, they infest only the larger animals such as cattle, sheep, horses, man, dogs, porcupines, goats, deer, and bears. Their predilection for areas on or along trails has been observed by officers of the Kamloops laboratory and by Holland (1940) and Philip (1953). The latter assigns this behaviour to a definite response to scent. Upon being brushed onto a host they rapidly crawl up to the head

and shoulders, where they usually attach within a matter of hours. Though the males take blood, they frequently move to new sites of attachment and do not engorge appreciably. The females usually remain at their original sites of attachment for about seven days, by which time each is fully engorged and nearly half an inch long. Mating takes place on the host, the act of which speeds up the feeding rate of the female (Gregson, 1944).

The engorged female drops from the host and lays several thousand eggs. The resulting larvae, or "seeds", like the ensuing nymphs, feed only upon small animals such as mice, ground squirrels, wood rats, chipmunks, and marmots. The life-cycle of this tick usually requires one to two years, depending on the availability of hosts. The peak of larval activity occurs about July, whereas the nymph is active throughout the summer.

D. andersoni is the most important tick in Canada because it is a serious menace to the welfare of both man and livestock. Besides causing tick paralysis, which has claimed over two dozen human lives in British Columbia and annually causes losses in livestock, this species is a vector of tularaemia, Colorado tick fever, and Rocky Mountain spotted fever. For some unknown reason the latter disease is largely limited to the United States.

D. andersoni is best distinguished from the two other species of *Dermacentor* in Canada by characters of its spiracular plates: *andersoni* has moderately large goblets as opposed to the large ones of *albipictus* and the small ones of *variabilis*. The nymphs of both *andersoni* and *variabilis* have the basis capituli drawn laterally into characteristic sharp points, but in the former the posterior margin of the basis is in the form of three shallow arcs and the scutum is evenly rounded posteriorly instead of showing a tendency to be pointed. These differences are slight, and distributional data are useful to the taxonomist.

Canadian records (peripheral only)

B.C. Elko, 5.VII.41, ex *Citellus* sp., 2N (J.P.)
Osoyoos, 23.V.41, ex man, 1♂ (J.D.G.)
Birken, 14.IV.40, ex *Tamiasciurus* sp., 1N (G.P.H.)
Redstone, 28.III.41, drag, ♀,♂ (J.D.G.)
Williams Lake 7.IV.44, ex *Microtus* sp., 2N (J.D.G.)
Berg Lake, 24.VII.44, ex *Citellus* sp., 1L (G.P.H.)
Isaac Cr., 10.VI.39, ex *Erethizon* sp., ♀, ♂ (J.D.G.)

Alta. Banff, 14.VII.39, ex *Ochotona princeps* ssp., 2N (J.D.G.)
Hanna, 30.II.40, ex *Citellus richardsoni,* 2♀, N (D.N.H.)
Cereal, 10.VI.41, ex *Citellus richardsoni,* 2N (D.N.H.)
Waterton L.8.VIII.47, ex *Eutamias* sp., 4L (D.N.H.)
Gorge Cr., 10.VI.53, ex *Ochotona princeps* ssp., 5N (J.H.B.)

Sask. Swift Current, 3.VII.50, ex *Citellus richardsoni,* 30L (D.N.H.)
Val Marie, 31.VI.44, ex *Cynomys ludovicianus,* 1♂ (D.N.H.)
Val Marie, 25.VIII.50, ex *Citellus richardsoni,* 1N (D.N.H.)
Cypress Hills, 12.VII.42, ex *Zapus princeps minor,* 1N (D.N.H.)
Coronach, 18.IX.41, ex man, A (C.I.P.R. No. 19)
Minton, - - -, ex *Citellus richardsoni,* (not seen) (G.D.B.)
Marquis, - - -, ex *Citellus richardsoni,* (not seen) (G.D.B.)
Edenwold, - - -, ex *Citellus richardsoni,* (not seen) (G.D.B.)

DERMACENTOR VARIABILIS (Say)

Fig. 23; Map II

Ixodes variabilis Say, 1821, p. 77.
Dermacentor variabilis, Banks, 1908a, p. 49.
Dermacentor venustus, McLeod, 1933, p. 111 and 124 (*nec* Banks, 1908a), *vide* Cooley, 1938, p. 26.
Dermacentor variabilis, Hearle, 1938, p. 353.
Dermacentor variabilis, Cooley, 1938, pp. 23-29.
Dermacentor variabilis, Bequaert, 1946, pp. 164-172.

Dermacentor variabilis is the eastern counterpart of *D. andersoni* in that it replaces the latter in eastern Saskatchewan and is found east as far as Nova Scotia. Although Cooley (1938) mentions that the ranges of *D. andersoni* and *D. variabilis* overlap in a north-to-south zone that, near the Canadian border, is stated to be a hundred miles wide, there is no evidence of such an area in Canada, and surveys of ticks conducted in 1950 and 1951 by the Province of Saskatchewan indicated a fifty-mile gap between the two species. This condition, however, may be artificial, because of the lack of hosts for adults in this grain-farming area. Its life-history is similar to that of *andersoni,* and small rodents are the hosts for the larval and nymphal stages. Originally, native deer and coyotes were doubtless responsible for the maintenance of this tick; now domestic dogs appear to be the main hosts. Consequently, this species is known as the American dog tick.

According to the life-history presented by Bequaert (1946), adults, nymphs, and larvae have been maintained alive under natural conditions for as long as 988, 377, and 273 days, respectively.

This tick may be a pest in eastern residential areas, and because of its potentialities for transmitting Rocky Mountain spotted fever and tularaemia, it may be considered of economic importance. Although it resembles *andersoni* closely, the adults are easily recognized by the fine stippled appearance of the goblets within the stigmal plates. In the nymphs the basal spurs of the capitulum are directed backwards, their posterior margins continuing in line with the base of the capitulum. In *andersoni* these three margins form distinct arcs.

Canadian records

Sask. Swift Current, 31.V.35, ex sheep, (possibly *andersoni*) (C.I.P.R. #15)
Cadillac, 16.VI.37, ex child, (possibly *andersoni*) (C.I.P.R. #15)
Kennedy, 3.VII.37, ex child, — (C.I.P.R. #15)
Carlyle Lake, 24.VI 42, drag, ♂♂, ♀♀ (G.P.H.)
Oxbow, ——, drag, (not seen) (G.D.B.)
Whitewood, ——, drag, (not seen) (G.D.B.)

Man. Winnipeg, -.VI.36, ex man, 2♀ (J.M.I.)

Ont. Grimsby, -.-.30, ex dog, 3♀, 2♂ (A.K.)
Brampton, -.XII.35, ex dog, 1♀ (———)
Vineland, 22.IV.38, ex dog, —— (W.C.G.)
Byron, -.VII.34, ex dog, 1♀ (Judd 1953)
Walpole Is., Guelph, Brantford, London, Chatham, Scotland, and Strathroy; all records from dog and man (Bequaert, 1946)

N.S. Sissiboo R., Digby Co., -.V.44, ex man, —— (C.I.P.R. #24)

DERMACENTOR ALBIPICTUS (Packard)

Fig. 22; Map II

Ixodes albipitus Packard, 1869, pp. 65-66.
Dermacentor albipictus, Banks, 1908a, pp. 44-45.
Dermacentor albipictus, Cooley, 1938, pp. 59-64.
Dermacentor albipictus, Hearle, 1938, p. 352.
Dermacentor erraticus var. *albipictus,* Bequaert, 1946, p. 175.
Dermacentor albipictus, Brown and Kohls, 1950, p. 198.

Dermacentor albipictus is one of the most widely distributed ticks in North America. Because of the variations in structures that frequently occurs in widespread species, particularly those in the genus *Dermacentor,* its classification has caused considerable confusion among taxonomists. The principal issue lies in the names *erraticus, nigrolineatus,* and *albipictus.*

When, in 1869, Packard described *Ixodes albipictus* from a moose from Nova Scotia he also described, in the same journal, *I. nigrolineatus* from northern New York. Banks (1908a), in reviewing *nigrolineatus,* states that

"quite possibly it is the *Ixodes erraticus* of Say (1821)", a tick that, apparently because of its meagre description, he recorded under "unplaced species" with the remark "it may be *Dermacentor nigrolineatus* Packard".

Cooley (1938) makes no mention whatsoever of *erraticus* in his treatise on the species of *Dermacentor* of the United States. Instead, he concludes from studies on an abundance of material that Packard's (1869) *albipictus* and *nigrolineatus* are synonymous, leaving *albipictus* by page priority.

Bequaert (1946) accepted the Banks (1908a) suggestion and reduced *nigrolineatus* Packard to synonymy with *Dermacentor erraticus* (Say). He felt "certain that Say's description could be no other". He then made Packard's *albipictus* a variety of *erraticus.*

In retaining the name of this tick as *albipictus,* the present writer has been influenced by Cooley's (1938) addendum on *D. albipictus,* in which it is shown that this species is subject to considerable variation in color and sclerotization. In Say's description the only significant features listed are the "acute black lines". In the light of the above, it is felt that this feature is not sufficient to separate the tick from *D. variabilis,* with which it might have been confused, even though the latter was described at the same time by the same author.

This species, which is known as the winter, moose, or horse tick, occurs abundantly in Northern Canada. In nature, moose and deer are the preferred hosts. Among domestic animals, horses often become severely infested, but cattle are seldom attacked. The only records of bites on man are from the rare transference to him of adults from their normal hosts. This tick makes its appearance in late autumn, when clusters of up to 300 larvae gather on the ends of grasses and twigs. The larvae are remarkably tolerant of snow and cold and unless brushed onto a host may remain in position until spring. The larvae and nymphs remain on the host after engorging instead of dropping to the ground like most ticks. Usually the ticks are not observed on horses until they are in their nymphal engorged state, when they are about the size of grains of rice and are blue-gray or dirty white in color. The adults that emerge from these become fully engorged by early spring, when they are frequently confused with recently attached and engorging *D. andersoni.* Like *andersoni,* they drop to the ground to oviposit. The local distribution of this species is dependent on the site of its hosts at the time the engorged females are dropping, and as a result the immature stages are usually found at the early spring feeding grounds of deer, and are particularly abundant along trails and at resting haunts.

Although this tick does not produce paralysis, it is believed by Wallace, Cahn, and Thomas (1933) to be the vector of various pathogenic organisms affecting big game, and that by means of disease and sheer numbers, or both, it inflicts severe losses among deer and moose.

As stated, this tick varies considerably in different areas, and it has been observed that specimens from Vancouver Island have spiracles with smaller goblets than those of the mainland. The former also appear to mature earlier (Cowan, 1946), though this may be due to the milder climate of the coastal region, since it is assumed that a tick's metabolism is suspended when it drops and remains in the snow, as must often be the case in the interior of British Columbia.

The characteristic hosts, behavior, and winter appearance of this tick assist greatly in its identification. The spiracles of the adults are typically rounded and divided into goblets much larger than those of either *andersoni* or *variabilis.* The basis capituli of the nymphs lack the sharp lateral points present in both these other species.

Canadian records

B.C. (selected records)
Campbell River, 21.XI.33, ex *Odocoileus hemionus columbianus,* 2♀, 6♂, 7N (G.J.S.)
Wellington, 4.I.26, ex cattle, 1♀ (W.D.)
Tatla Lake, 28.III.41, ex *Odocoileus* sp., AA (J.D.G.)
Quesnel, 20.III.39, ex *Alces* sp., AA (J.D.G.)
Upper Nechako, 24.III.35, ex *Alces* sp., AA (P.B.)
Clinton, 27.II.30, ex horse, 4♀, 3♂, 5N (G.J.S.)
Vavenby, 10.II.29, ex *Canis latrans lestes,* 1♀ (T.K.M.)
Newgate, 25.I.38, ex cattle, AA (—).

Alta. Jasper, 18.VI.40, drag, 1♀ —.
Banff, 28.IV.43, ex *Odocoileus* sp., 1♂ (I.McT.C.)
Wainwright, ——, ex *Bison b. bison,* AA (J.H.B.)

Sask. Regina, -.XII.32, ex *Alces,* sp., N (F.G.B.)
Lac la Ronge, 26.V.35, ex *Rangifer* sp., 3A (S.J.L.)
Prince Albert Park, 2.V.35, ex *Ursus* sp., 2♀ (S.J.L.)

Ont. Sudbury Dist., 5.IV.51, ex *Odocoileus* sp., 8♂, 5♀, 5N (D.M.D.)
North Bay, -.-.51, ex *Odocoileus* sp., 3♂, 15♀ (D.M.D.)
Sioux Lookout, 25.IV.50, ex *Alces* sp., AA (D.M.D.)
Kapuskasing, 5.III.38, ex *Alces* sp., AA (R.V.W.)

Nova Scotia —, 21.I.49, ex *Alces* sp., A, N (——)
New Glasgow, 8.VI.35, ex *Alces* sp., 4♀ (J.B.M.)

New Brunswick
Blissville, 15.IV.35, ex cow, AA (——)
Cookville, 26.IV.32, —— AA (——)
Fredericton, 8.V.33, ex *Alces* sp., AA (C.I.P.R.)

Genus *Rhipicephalus* Koch

Genotype: *Rhipicephalus sanguineus* (Latreille)
Rhipicephalus Koch, 1844, p. 238.
Rhipicephalus, Nuttall *et al.,* 1911, p. 122.
Rhipicephalus, Cooley, 1946a, p, 23.

Usually inornate, with prominent eyes and festoons. Anal grooves posterior to anus, with a median postanal groove. Basis capituli hexagonal dorsally. Palpi short. Coxa I deeply bifid. Males with one pair of adanal shields and usually a pair of accessory shields.

RHIPICEPHALUS SANGUINEUS (Latreille)

Figs. 36, 37, 38, 39, 40; Plate I, fig. 7; Map VII
Ixodes sanguineus Latreille, 1806, p. 157.
Rhipicephalus sanguineus (Latreille), Koch, 1844, pp. 238-239.
Rhipicephalus sanguineus, Bequaert, 1946, pp. 160-163.
Rhipicephalus sanguineus, Cooley, 1946a, pp. 24-29.

Rhipicephalus sanguineus, the brown dog tick, is one of the most widely distributed ticks in the world. After man's colonization of the New World it spread rapidly, and it is now present in the greater portion of eastern United States as well as a number of the western states (Kohls and Parker, 1948). During recent years it has been recorded in a number of localities in Eastern Canada. Because its usual host is the dog, infestations in houses are frequent. In such instances, man may become an accidental host. Less common host records include rabbits, deer, and mules.

This tick is easily recognized by its prominent eyes and hexagonal basis capituli. The males bear distinctive adanal and accessory shields.

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Canadian records

Ont. Espanola, Nipissing D., 11.III.40, ex dog (C.R.T.)
Guelph, ——, ex dog, 2♀, 2♂, 2N (——)
Colbourg, 4.VII.49, ex dog, 7♀ (T.M.H.♂)
Espanola, ——, ex dog, —— (C.I.P.R. #18)
Toronto, ——, ex dog, ——(C.I.P.R. #24)
Ottawa, ——, ex dog, —— (C.I.P.R.)

N.S. Baddeck, C. B. Is., -.VIII.39, ex dog, ♀ (M.H.G., Beq. '46)
——, -. VII.34, ex dog, 1♀ (A.L.S.)

Que. Montreal, 27.II.45, ex dog, —— (——)
Mount Royal, 31.IX.45, ex dog, —— (C.I.P.R. #23)

Genus *Haemaphysalis* Koch

Figs. 25, 26, 27
Genotype: *Haemaphysalis concinna* Koch
Haemaphysalis Koch, 1844, p. 237.
Haemaphysalis, Nuttall *et al.,* 1915, p. 349.
Haemaphysalis, Cooley, 1946a, p. 30.

Inornate ticks without eyes, but with festoons. Anal grooves posterior to anus. Palps short and conical, giving the capitulum a triangular appearance. Coxa I never bifid. Male with no ventral plates. This large genus is represented by only two species in North America.

HAEMAPHYSALIS LEPORIS-PALUSTRIS (Packard)

Figs. 28, 29, 30, 31; Plate I, fig. 3; Map III
Ixodes leporis-palustris Packard, 1869, p. 67 .
Haemaphysalis leporis-palustris (Packard) Nuttall *et al.,* 1915, pp. 387-394.
Haemaphysalis leporis-palustris, Hearle, 1938, p. 352.
Haemaphysalis leporis-palustris, Brown, 1944, p. 48.
Haemaphysalis leporis-palustris, Cooley, 1946a, pp. 31-36.
Haemaphysalis leporis-palustris, Bequaert, 1946, pp. 194-199.
Haemaphysalis leporis-palustris, Brown and Kohls, 1950, pp. 198-199.

This species is widely distributed in Canada. Rabbits are the main host, but it has been taken from a wide variety of small birds and mammals and may frequently infest upland game birds. Brown (1945) cites one instance of it engorging on man. In rabbits, large numbers of all three stages may be found at the same time on the same animal. The ears and face appear to be favorite sites of attachment. It occasionally attacks chickens (Bishopp and Trembley, 1945). This tick is an important transmitter of tularaemia and is undoubtedly one of the main vectors of this disease in wildlife.

Canadian records

B.C. (Selected records)
White Rock, 6.IX.39, ex turkey, (——)
Salmon Arm, 29.IX.24, ex grouse, 15N, 14L (E.R.B.)
Rayleigh, 5.VIII.31, ex grouse, 1L (T.K.M.)
McLure, 8.X.40, ex *Tamaisciurus* sp., 1L (——)
Vavenby, 23.IV.31, ex *Lepus americanus* ssp., 1♀ (R.T.)
Osoyoos, 22.V.41, ex wren, 1N (——)
Chezacut, 3.VIII.31, ex *Lepus americanus* ssp., 1♀ (K.R.)
Pavilion, 25.VIII.33, ex *Lepus americanus* ssp., 11N, 25L (T.K.M.)
Falkland, 7.IV.30, ex *Corvus brachyrhynchos,* 1L (H.M.)
Agassiz, 12.VIII.34, ex grouse, 6♀, 11N, 2L (——)
Vancouver, 16.V.35, ex *Zonotrichia coronata,* 1L (R.A.C.)
Vancouver, 27.IV.35, ex *Zonotrichia leucophrys pugetensis,* 1N, 1L (R.A.C.)

Alta. High River, 10.V.38, ex rabbit, 1♀ (E.C.)
Elkwater L., 18.VII.39, ex rabbit, 2♀, 7N, 5L (——)
Wainwright, ——, ex rabbit, 2♀, 7N, 5L (——)
Waterton L., 23.VI.38, ex rabbit, 1♂, 1N (——)

Sask. Indian Head, 27.IV.26, ex rabbit, 8♀, 4♂ (E.H.)
Estevan, 18.VII.42, ex rabbit, 1N (G.P.H.)
Valeport, 9.VI.32, ex rabbit, —— (F.G.B.)

Man. Makanak, 4.VIII.42, ex rabbit, —— (J.B.W.)
Waboden, 20.V.49, ex rabbit, —— (J.B.W.)
Pikwitone, 26.V.49, ex rabbit, —— (J.B.W.)

Ont. Toronto, ——, ex turkey, 3N (W.A.M.)
L. Sasajewan, 1.VII.49, ex rabbit, 1N (D.M.D.)
L. Sasajewan, 6.VII.49, ex grouse, 1N (D.M.D.)
Manitoulin Is., 11.V.51, ex rabbit, 29♀, 5♂, 1N (D.M.D.)
St. Peter L., 28.VI.48, ex grouse, 2N, 1L (D.M.D.)
Arden, 11.X.33, ex *Strix varia,* 3N (D.M.D.)
L. Nipissing, 21.VII.32, ex rabbit, 3♀ (D.M.D.)
Batchewana, 13.VII.35, *Tamiasciurus hudsonicus loquax,* 3♀ (D.M.D.)
Glenelg Twp., 13.VI.51, ex *Lepus europaeus,* (Judd 1953)

N.B. Scotch Cr., -.X.32, ex rabbit, 4N, 4L (M.H.M.)
Fredericton, 21.VII.39, ex rabbit, —— (A.G.)
Pr. Wm. St. York Co., ——, ex grouse, L (C.N.C.)
Jeffrey Co., ——, ex rabbit, 1♀ (C.N.C.)

N.S. Queens Co., ——, ex grouse, —— (C.N.C.)
Wolfville, 27.VII.34, ex warbler, N (R.W.S.)
Wolfville, 4.IX.33, ex *Turdus migratorius,* N (R.W.S.)

Newfoundland
St. Johns, 30.VII.50, ex rabbit, —— (——)

HAEMAPHYSALIS CHORDEILIS (Packard)

Figs. 32, 33, 34, 35; Map III

Ixodes chordeilis Packard, 1869, p. 67.
Haemaphysalis punctata var. *cinnabarina,* Neumann, 1905 (*nec* Koch, 1844), p. 237.
Haemaphysalis cinnabarina, Nuttall *et al.,* 1915 (*nec* Koch, 1844), p. 372.
Haemaphysalis cinnabarina, Hearle, 1938 (*nec* Koch, 1844), p. 352.
Haemaphysalis cinnabarina, Brown, 1944 (*nec* Koch, 1844), p. 49.
Haemaphysalis chordeilis, Cooley, 1946a, pp. 37-43.
Haemaphysalis chordeilis, Bequaert, 1946, pp. 191-194.
Haemaphysalis chordeilis, Brown and Kohls, 1950, p. 198.

Haemaphysalis chordeilis is the common bird tick in Canada, where, except in the Pacific coast wet belt, it occurs abundantly on upland game birds. It has also been recorded from rabbits, cattle, man, and a variety of small birds. It is of economic importance as a parasite of turkeys and a vector of diseases of wild life.

Though similar in size and general appearance to those of *H. leporis-palustris,* the female, nymphs, and larvae of *chordeilis* are distinguished by having a less strongly reflexed posterior edge on palpal article 2, and by lacking ventral cornua. The basis capituli of the nymph of *chordeilis* is hexagonal, as opposed to the rectangular shape in *leporis-palustris.* The males of *chordeilis* are distinguished by a long internal spur on Coxa IV.

Canadian records

B.C. (selected records)
Jamieson Creek, 3.VIII.31, ex *Tamiasciurus hudsonicus streatori,* 1♂, 4L (R.T.)
Trapp L., 5.VIII.30, ex grouse, 1N (H.M.)
Salmon Arm, 27.IX.24, ex grouse, 1♀ (E.R.B.)
Paul L., 15.IX.35, ex grouse, —— (G.J.S.)
Rayleigh, 16.VII.37, ex *Marmota flaviventris avara,* 1♂ (J.D.G.)
Okanagan Ldg., 9.IX.38, ex grouse, 2♀ (A.B.)
Kamloops, 28.VII.50, ex horse, 1♀ (J.D.G.)
Vernon, 20.XI.50, ex child, 1♀ (——)

Alta. Aden, 21.V.51, drag, 3♀ (J.H.B.)
Medicine Hat, 4.V.42, drag, 2♂, 4♀ (J.D.G.)
Seven Persons Coulee, 9.V.51, drag, 2♂, 5♀ (J.H.B.)

Sask. Weyburn, 2.III.14, ex cattle (?), 22♀ (C.N.C.)

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Man. Teulon, 10.VII.33, ex turkey, 4♀, 1♂ (A.U.M.)
Winnipeg, ——, ex hen, ♀, ♂ (C.N.C.)
Treesbank, -.X.36, ex prairie chicken, 1♂ (N.C.)
Ont. Sasajewan L., 6.VII.49, ex grouse, 2♂, 8♀, 10N (D.M.D.)
Sasajewan L., 15.VII.49, ex grouse, 1♂ (D.M.D.)
Sasajewan L., 9.VIII.49, ex grouse, 1♀ (D.M.D.)
L. St. Peter, 28.VI.48, ex grouse, 1♂ (D.M.D.)
N.B. ——, 6.VII.37, ex grouse, —— (C.I.P.R. #15)

Genus *Ixodes* Latreille

Figs. 41, 42, 43, 44, 45
Genotype: *Acarus ricinus* Linnaeus, 1758
Ixodes Latreille, 1795.
Ixodes, Nuttall *et al.*, 1911, p. 116.
Ixodes, Cooley and Kohls, 1945, p. 7.

Inornate ticks, lacking eyes and festoons. Anal grooves embracing anus anteriorly. Palpi variable in form. Coxæ about equal in size; spurs variable or absent. Males with seven non-salient ventral plates. Eighteen species are known to occur in Canada—more than in all the other genera represented in Canada.

IXODES PACIFICUS Cooley and Kohls

Figs. 46, 47, 48, 49, 50, 51, 52, 53, 54, 55; Plate I, figs. 8, 9; Map IV
Ixodes californicus Banks, 1908a, (*nec* Banks, 1904), p. 24.
Ixodes ricinus californicus, Kohls and Cooley, 1937 (*nec* Banks, 1908a), pp. 282-283.
Ixodes ricinus, Hearle, 1938 (*nec* Linneaus, 1758), p. 351.
Ixodes californicus Gregson, 1942a (*nec* Banks, 1908a), pp. 3-5.
Ixodes californicus Gregson, 1942d (*nec* Banks, 1908a), pp. 5-6.
Ixodes pacificus Cooley and Kohls, 1943, pp. 139-144.
Ixodes pacificus Cooley and Kohls, 1945, pp. 21-28.

According to Cooley and Kohls (1943), Banks (1908a) in "redescribing" *Ixodes californicus* Banks, 1904 (which was based on nymphal specimens only) had before him males and females of another species. For this second species they provided the name *pacificus*.

This is the only *Ixodes* species of notable economic importance in Canada. Its distribution is limited to localized areas along the southern British Columbia coast. Typical of these are the Malahat district, the West Vancouver district (from West Bay to Horseshoe Bay), Harrison Bay (near Agassiz), and Cultus Lake. These areas are usually characterized by damp, sunny, rocky slopes supporting such vegetation as *Sedum* and *Mimulus* spp., *Cryptogramma acrostichoides* (rock brake fern), *Spiraea* spp., and *Arbutus menziesii*. The tick is so adapted to the moist climate of its habitat that it is maintained with difficulty in the laboratory at Kamloops. It seems to be a short-lived tick; even in its normal habitat unfed adults have been observed to die within a few months.

The larvae and nymphs of *pacificus* were shown by Jellison (1934) and Gregson (1935) to feed on lizards (*Gerrhonotus* sp.). Warm-blooded hosts such as small birds and mice are rarely infested by these stages. The adults, which mate before feeding, attach to deer (Cowan, 1946), dogs, cats, sheep, and man, sometimes causing painful, slow-healing sores. Because of the relatively long hypostome of this species, attached females are difficult to remove. A continuous twisting of the tick in one direction is recommended when the application of oils or heat fails to dislodge it. A careful examination should be made to determine that the entire mouth parts have been removed. The males attach briefly but repeatedly, and leave irritating sores at the sites of their bites. The prevalence of this species in heavily populated areas close to Vancouver and Victoria has made it a hated pest of man and his pets

(Gregson, 1942a). Fortunately, as residential districts have become established, the tick has decreased in numbers, Because of the similarity in habits and morphology of this tick to the European castor bean tick *I. ricinus* L., it may be considered a potential vector of such livestock diseases as red water and louping ill.

Unengorged females of *I. pacificus* are easily separated from other species by their red-brown bodies and black legs, capitulum, and scutum. Upon feeding, their integument assumes a dull-gray texture. The males are black, and about half the size of the unfed female. The main season of adult activity lasts from early fall till late spring. As a rule they are absent during the dry summer period.

Canadian records

B.C. (selected records)
Malahat, 14.III.32, ex man, 6♀, 8♂ (Mrs. Y.)
Duncan, 25.XII.10, ex dog, 1♂, 1♀ (S.H.)
Wellington, 14.IX.29, ex man, 1♂ (W.D.)
Courtenay, 19.V.33, ex man, 1♀ (J.D.G.)
West Vancouver, 6.X.33, ex *Gerrhonotus coeruleus principis,* NN (J.D.G.)
Gambier Is., 21.II.43, *Tamiasciurus* sp., —— (G.P.H.)
Pender Hbr., 28.V.29, ex man, 1♀ (R.T.)
Retreat Cove, 12.IV.35, drag, ♀♀ (T.K.M.)
Powell R., 10.V.35, ex man, 1♀ (G.P.H.)
Ocean Falls, 22.XI.34, ex man, 1♀ (J.K.J.)
Harrison Bay, 26.V.40, drag, ♀♀ (J.D.G.)
Agassiz, -.V.32, ex man, 3♀ (J.D.G.)
Yale, 17.IV.35, drag, 1♂ (J.D.G.)
Chapmans, -.IV.40, ex dog, 1♀ (Mrs. C.)

IXODES SPINIPALPIS Hawden and Nuttall

Figs. 129, 130, 131, 132, 133, 134, 135, 136, 137, 138; Map IV
Ixodes diversifossus, Neumann, 1911 (*nec* Neumann, 1899), pp. 14-15.
Ixodes diversifossus, Bishopp, 1912 (*nec* Neumann, 1899), pp. 30-32.
Ixodes dentatus var. *spinipalpis* Hadwen and Nuttall, *in* Nuttall, 1916, pp. 301-304.
Ixodes dentatus var. *spinipalpus* [sic], Hearle, 1938, p. 350.
Ixodes spinipalpis, Cooley and Kohls, 1942, pp. 1733-1736.
Ixodes spinipalpis, Cooley and Kohls, 1945, pp. 51-56.
Ixodes spinipalpis, Brown and Kohls, 1950, p. 201.

I. spinipalpis appears to be confined mainly to the Pacific coast region, though it has been taken in the Rocky Mountains, both in Canada and the United States. Its hosts are common and varied, and include wood rats, rabbits, squirrels, pikas, mice, shrews, and even small birds, but the tick is relatively rare. The sharp, recurved auriculae and long palps help to identify this species.

Canadian records

B.C. Black Mt., 8.VIII.34, ex *Ochotona princeps brunnescens,* 3N (J.D.G.)
Lulu Is., 21.IV.32, ex *Hylocichla guttata,* 1N (J.D.G.)
Coquitlam, 26.IV.41, ex *Eutamias* sp., L (J.D.G.)
Cultus L., 6.II.36, ex *Lepus* sp., 1♀, 1N (D.L.)
Silver Cr., 30.V.34, ex *Peromyscus* sp., N, L (J.D.G.)
Silver Cr., 31.V.34, ex *Neotoma cinerea occidentalis,* N (J.D.G.)
Alta L., -.VIII.32, ex *Ochotona princeps brunnescens,* 5♀, 3♂, 4N, 2L (K.R.)
Birken, 15.IV.40, ex *Peromyscus* sp., N, L (G.P.H.)
Oliver, 30.V.41, ex *Lepus* sp. L (J.D.G.)
Osoyoos, 12.V.42, ex *Reithrodontomys megalotis nigrescens,* 1N (G.P.H.)
Okanagan Ldg., 10.VIII.40, ex *Peromyscus* sp., 2N (G.P.H.)
Vavenby, 16.IV.40, ex *Ixoreus naevius,* 1N (J.D.G.)
Vancouver, 16.V.35, ex *Zonotrichia coronata,* 2L (R.A.C.)
Alta. Rocky Mt. House, 7.VIII.47, ex *Sorex* sp. (Brown and Kohls 1950)

IXODES ANGUSTUS Neumann

Figs. 102, 103, 104, 105, 106, 107, 108, 109, 110; Maps III, IV

Ixodes angustus Neumann, 1899, p. 136.
Ixodes angustus, Nuttall *et al.,* 1911, pp. 195-198.
Ixodes angustus, Hearle, 1938, p. 349.
Ixodes angustus, Cooley and Kohls, 1945, pp. 69-76.
Ixodes angustus, Bequaert, 1946, p. 147.
Ixodes angustus, Brown and Kohls, 1950, p. 199.

This is one of the commonest species of *Ixodes* in British Columbia. Though best known from the Pacific coast, it is found throughout Canada. Beyond, it ranges from Alaska to California, and east to New York State. According to Cooley and Kohls (1945), this species shows considerable variation in morphological characters. It is the commonest species of tick on British Columbia coast squirrels (*Tamiasciurus douglasii mollipilosus*) but is replaced in the interior dry belt by *I. hearlei.* It occurs in the wet belt in eastern British Columbia. Large numbers of all stages are frequently found on Pacific coast mice, voles, and moles. It has also been taken from pikas, shrews, rabbits, and wood rats. There are two British Columbia and three United States records (Cooley 1946b) of this tick biting humans.

It is distinguished from the closely allied pika tick, *I. ochotonae,* by having the hypostome teeth in files of 3/3 instead of 2/2. The nymphs and larvæ differ greatly from the adults in having an anterior and a posterior horn at the base of each palpal article I. The diamond-shaped structure so formed is longer and more conspicuous in this species than in *soricis, marmotæ, kingi,* or *sculptus.*

Canadian records

B.C. (selected records from 200 collections)
Malahat, 5.VIII.34, ex *Tamiasciurus hudsonicus vancouverensis,* 1♀, 5N, 5L (——)
Mt. Arrowsmith, 24.V.40, ex *Tamiasciurus h. vancouverensis,* 2♀ (——)
Triangle Is., 25.VI.49, ex *Microtus* sp., —— (G.C.C.)
Vancouver, 15.VIII.40, ex *Microtus* sp., 14N (——)
Burnaby, 5.VI.53, ex man, 1♀ (G.J.S.)
Whytecliff, 10.VIII.34, ex *Sorex* sp., 1♀, 3N, 6L (J.D.G.)
Black Mt., 5.VII.36, ex *Lepus* sp., 1♂, 1N (J.D.G.)
New Westminster, 13.VI.52, ex domestic cat, 1♀ (G.J.S.)
Mission, 4.VII.53, ex man, 1♀ (G.J.S.)
Cultus L., 3.IV.36, ex *Peromyscus maniculatus* ssp., 1♀ (D.L.)
Lytton, 30.VIII.31, ex *Neotoma cinerea occidentalis,* 1N (G.J.S.)
Birken, 31.VII.31, ex *Tamiasciurus* sp., 2♀ (G.P.H.)
Tetana L., ——, ex *Glaucomys sabrinus* ssp., 1♀ (J.F.S.F.)
Vavenby, 30.VI.35, ex *Tamiasciurus hudsonicus* ssp., 1♀ (J.D.G.)
Okanagan Cntr., 5.V.37, ex *Microtus pennsylvanicus* ssp., 1N (J.D.G.)
Salmon Arm, 24.IX.37, ex *Peromyscus maniculatus artemesiae,* 2♀, 1♂ (J.D.G.)
Isaac Cr., 9.VI.39, ex *Tamiasciurus hudsonicus* ssp., 1N (J.D.G.)
Kinbasket L., 4.VIII.43, ex *Tamiasciurus hudsonicus* ssp. 2N (G.P.H.)
Nakusp, 2.IV.44, ex *Peromyscus maniculatus* ssp., 1♀ (J.D.G.)
New Denver, 33.VI.49, ex *Peromyscus maniculatus* ssp., —— (——)

Alta. Peace R., 15.VI.38, ex *Microtus* sp., 1♀ (——)
Faust, 20.VIII.48, ex *Clethrionomys gapperi* ssp., —— (Brown and Kohls 1950)
Elkwater, 7.XI.30, ex *Zapus* sp., 1♀, 1♂ (——)
Cold Lake, 15.VIII.50, ex *Peromyscus maniculatus* ssp., 1♀ (J.H.B.)

Sask. Cypress Hills, 12.VII.42, *Zapus p. saltator,* 1N, 1L (——)

Man. The Pas, 18.VI.48, ex *Microtus* sp., 1♀ (J.B.W.)

Ont. Brule L., 23.VII.34, ex *Parascalops breweri,* 4N, 4L (D.M.D.)
Brule L., 6.VIII.34, ex *Parascalops breweri,* 1N, 1L (D.M.D.)
Sasajewan L., 30.VII.49, ex *Tamias striatus lysteri,* 1♀ (D.M.D.)
Sasajewan L., 23.VII.50, ex *Peromyscus maniculatus gracilis,* 1♀ (D.M.D.
Cache L., 30.VII.35, ex *Peromyscus maniculatus gracilis,* 1♀ (D.M.D.)
Brule L., 25.VII.34, ex *Synaptomys cooperi cooperi,* 1♀ (D.M.D.)
Sasajewan L., 7.VII.49, ex *Clethrionomys g. gapperi,* 1♀ (D.M.D.)

Biggar L., 26.VII.33, ex *Clethrionomys g. gapperi,* 1N (D.M.D.)
Batchewana, 14.VII.35, ex *Blarina brevicauda talpoides,* 1N (D.M.D.)
Wilmot Twp., 23.VII.49, ex *Blarina brevicauda talpoides,* 1N, 6L (D.M.D.)
Batchewana, 10.VIII.35, ex *Eutamias minimus neglectus,* 1♀ (D.M.D.)
Batchewana, 10.VIII.35, ex *Tamiasciurus hudsonicus loquax,* 1N (D.M.D.)
Milton, 22.IV.35, ex *Peromyscus leucopus novaboracensis,* 6♀ (D.M.D.)
Dundas, 8.VII.47, ex *Peromyscus* sp., —— (Judd 1950)

Que. Rupert House, 22.VI.49, ex *Microtus* sp., 1♂ (C.N.C.)
Rupert House, 12.VII.49, ex *Clethrionomys* sp., 1♀, 2N, 2♂ (E.J.R.)
Rupert House, 12.VII.49, ex *Zapus* sp., N (E.J.R.)

N.S. Folly L., 22.VIII.35, ex squirrel, 1♀ (R.W.S.)

IXODES SORICIS Gregson

Figs. 120, 121, 122, 123, 124, 125, 126, 127, 128; Map IV

Ixodes soricis, Gregson, 1942b, pp. 137-139.
Ixodes soricis, Cooley and Kohls, 1945, pp. 149-152.
Ixodes soricis, Gregson and Kohls, 1952, pp. 185-188.

Ixodes soricis is the smallest known species of *Ixodes* in North America, the unengorged female being little more than 1 mm. in length. Engorged specimens are whitish in color, nearly spherical in shape, and about 4 mm. in diameter. In Canada it appears to be restricted mainly to the Pacific coast, although in the United States it has been recorded by Jameson (1946) as occurring southeast to Idaho Springs, Colorado. Except for one collection from *Thomomys talpoides* ssp., its only known hosts are various species of shrews. Gregson (1949c), and Gregson and Kohls (1952) cite an unusual attachment of a male to the integument of an engorging female of this species. Apart from its small size and faint longitudinal wrinkles in the posterior area of the scutum of the female, this tick is remarkably similar to *I. angustus.*

Canadian records

B.C. Comox, V.I., 14.XII.39, ex *Sorex* sp., 1♀ (——)
Quatsino, V.I., 24.VI.49, ex *Sorex* sp., 1♀ (C.J.G.)
Powell R., 19.VIII.29, ex *Sorex* sp., 2♀ (K.R.)
Aldergrove, 24.VIII.30, ex *Sorex v. vagrans,* 1♀ (K.R.)
Harrison Bay, 13.X.42, ex *Sorex* sp., 1♀ (J.D.G.)
Whytecliff, 9.VIII.36, ex *Sorex* sp., N, L (J.D.G.)
Point Grey, 12.XI.38, ex *Sorex* sp., 1♀ (——)
Silver Cr., 26.IV.42, ex *Sorex* sp., 1♀ (J.D.G.)
Silver Cr., 29.III.48, ex *Sorex* sp., 1♀, 1♂ (G.P.H.)
Alta L., 9.VIII.32, ex *Sorex obscurus setosus,* 1♀ (K.R.)
Alta L., 30.VIII.41, ex *Sorex* sp., 2♀ (K.R.)
Copper Cr., 8.V.42, ex *Sorex* sp., 1N (J.D.G.)
Creston, 17.VIII.49, ex *Sorex cinereus* ssp., 1♀ (I.McT.C.)

IXODES OCHOTONAE Gregson

Figs. 111, 112, 113, 114, 115, 116, 117, 118, 119; Map IV

Ixodes ochotonæ, Gregson, 1941b, pp. 224-228.
Ixodes ochotonæ, Cooley and Kohls, 1945, pp. 139-144.

This species might well be called the pika tick since, with few exceptions, all records are from this host. The adult ticks resemble *I. angustus* closely, the difference in the dentition of the hypostome (2/2 in *ochotonæ,* 3/3 in *angustus*) and a milder crenulation in that of the male in the first species being the only easy means of their separation. The nymphs of *ochotonæ* are readily recognized by the lack of the anterior horn of the inner plate on palpal article I.

Canadian records

B.C. Tappen, 23.V.38, ex *Ochotona princeps* ssp., 1N (J.D.G.)
Salmon Arm, 4.III.30, ex *Ochotona princeps* ssp., 2N, 2L (J.D.G.)
Lumberton, 15.IV.41, ex *Ochotona princeps* ssp., 2N (J.D.G.)
Nicola, 26.VIII.32, ex *Ochotona princeps* ssp., 2N, 1L (T.K.M.)
Copper Cr., 8.V.42, ex *Ochotona princeps* ssp., 1♀, 1N (J.D.G.)
Kinbasket L., 6.VIII.43, ex *Microtus* sp., N (J.D.G.)
Glacier, 3.VIII.50, ex *Ochotona princeps* ssp., N (T.K.B.)

Alta L., 40.VIII.41, ex *Ochotona princeps* ssp., ♀1 (K.R.)
Wigwam, 11.VI.39, ex *Neotoma cinerea occidentalis,* 1N (J.D.G.)
Gray Cr., 5.VI. 36, ex *Ochotona princeps* ssp., 2♀, 1N, 1L (T.K.M.)
Pavilion L., 5.VII.50, ex *Neotoma cinerea occidentalis,* 1N (J.D.G.)
Hanceville, 6.X.53, ex *Ochotona princeps* ssp., 10N, 3L (L.J.)

IXODES RUGOSUS Bishopp

Figs 185, 186, 187, 188, 189, 190, 191, 192, 193, 194; Map V
Ixodes cookei var. *rugosus,* Bishopp, 1911, p. 197.
Ixodes hexagonus, Hewitt, 1915 (*nec* Leech [sic.] 1815), p. 227.
Ixodes hexagonus var. *cookei,* Hewitt, 1915 (*nec* Packard 1869), p. 227.
Ixodes cookei var. *rugosus,* Nuttall, 1916, p. 334.
Ixodes hexagonus, Hearle, 1938 (*nec* Leach, 1815), p. 350.
Ixodes hexagonus var. *cookei,* Hearle, 1938 (in part) (*nec* Packard, 1869), p. 350.
Ixodes rugosus, Cooley and Kohls, 1945, pp. 119-123.

This is a Pacific coast tick, never having been taken east of the Coast Mountains in its recorded distribution from California to British Columbia. It is known only from carnivores. Available British Columbia specimens are all from coyotes or skunks. This tick resembles *texanus* in its rugged features, but is readily distinguished by its long internal coxal spur. Hewitt (1915) considered ticks collected by Hadwen from weasel and dog at Mt. Lehman, B.C., to be of *I. hexagonus* Leach and *I. hexagonus* var. *cookei* Packard, and Hearle (1938) identified a tick from a dog at Mt. Lehman as of the latter. Although the writer has not examined these specimens, he considers, from the hosts and the nature of the determinations, that they were of *rugosus.*

Canadian records

B.C. Cultus Lake, 30.XII.35, ex *Spilogale phenax olympica,* 1N (D.L.)
Mission, 24.IV.41, ex *Canis latrans* ssp., 2♀, 14N (J.D.G.)
Vancouver, 1.XI.40, ex *Spilogale phenax olympica,* NN (I.McT.C.)
Huntington, 27.XI.42, ex *Spilogale phenax olympica,* 1N (——)
Huntington, 27.V.50, ex *Spilogale phenax olympica,* 3N, 1L (J.D.G.)
Harrison Bay, 21.III 49, ex *Spilogale phenax olympica,* 1♀ (——)

IXODES TEXANUS Banks

Figs. 74, 75, 76, 77, 78, 79, 80, 81, 82; Maps III, IV
Ixodes texanus Banks, 1908b, pp. 172-173.
Ixodes texanus, Nuttall *et al.,* 1911, pp. 214-216.
Ixodes texanus, Hadwen, 1912, pp. 93-99.
Ixodes texanus, Hewitt, 1915, p. 229.
Ixodes texanus, Hearle, 1938, p. 352.
Ixodes texanus, Cooley and Kohls, 1945, pp. 77-83.
Ixodes texanus, Bequaert, 1946, pp. 159-160.

Although this tick is one of the most widely distributed species of *Ixodes* in the United States, in Canada it appears to be restricted mainly to British Columbia, where it is a common parasite of mustelids. The only eastern records are those of specimens from a mink farm, and of a nymph from a racoon, both from Ontario. This is an extremely hardy tick, and, as mentioned by Gregson (1949b), specimens of each stage have been kept alive without food for seven years.

Though the humped shoulders of the hypostome of the female of this tick have been considered a character of the species, Mr. G. M. Kohls of the Rocky Mountain Laboratory, Montana, has recently permitted the writer to examine specimens of ticks from spotted skunks from Utah, Arizona, and California, which, though resembling *texanus* in all other respects, have sloping hypostome shoulders like *hearlei.* Unless these ticks are considered as of a new species, this feature of the hypostome appears to be variable outside of Canada.

Canadian records

B.C. Mt. Lehman, 16.I.10, ex *Procyon lotor pacifica,* 1♀ (S.H.)
Kamloops, 12.IV.30, ex weasel, 1♀, 1N (E.H.)
Kamloops, 12.XI.49, ex weasel, N, L (J.D.G.)
Tranquille, 28.VII.33, ex weasel, 1N, 75L (D.C.)
Monte Creek, 7.VII.29, ex weasel, 4♀, 124N, 3L (I.McT.C.)
Nicola, 28.VIII.32, ex weasel, 4N, 5L (R.T.)
Nicola, 1.IX.32, ex weasel, 14N (J.D.G.)
Powell River, 16.IV.35, ex *Mustela vison* ssp., 2♀ (D.L.)
Vernon, 20.IV.40, ex dog, 1♀ (H.B.L.)
Ewings Landing, 15.X.41, ex dog, 1N, (J.D.G.)

Ont. Brampton, 28.XII.49, ex *Procyon lotor lotor,* 1N (D.M.D.)
Kirkfield, -.-.-, ex *Mustela vison* ssp., 2♀ (Bequaert 1946)

IXODES HEARLEI Gregson

Figs. 83, 84, 85, 86, 87, 88, 89, 90, 91; Map V

Ixodes marxi, Hearle, 1938 (*nec* Banks, 1908a), p. 350.
Ixodes hearlei, Gregson, 1941b, pp. 220-224.
Ixodes hearlei, Cooley and Kohls, 1945, pp. 85-90.

Hearle first recognized the likelihood of this being a new species, although he tentatively designated specimens as of *marxi,* the eastern squirrel tick, which this species closely resembles. However, in *hearlei* the scutum is shorter and the auriculae less prominent. Moreover, the ranges of *hearlei* and *marxi* are separated by the Great Plains. Because of their overlapping distributions and other points of similarity, if hosts are disregarded, *hearlei* is more apt to be confused with *texanus,* though the former is easily distinguishable by the sloping shoulders of the hypostome. Moreover, *hearlei* is smaller and less robust than *texanus.*

In British Columbia *hearlei* has been found only on the Streator pine squirrel, *Tamiasciurus hudsonicus streatori.* It has not been taken east of this province. The fed ticks are distinctively elongated.

Canadian records

B.C. (selected records from 45 collections)
Avola, 2.IX.32, ex *Tamiasciurus hudsonicus streatori,* 7N (T.K.M.)
Birken, 13.IV.40, ex *Tamiasciurus hudsonicus streatori,* 1♀, N, L (G.P.H.)
Riske Cr., 29.VI.30, ex *Tamiasciurus hudsonicus streatori,* 3♀ (G.J.S.)
Boston Bar, 25.IV.40, ex *Tamiasciurus hudsonicus streatori,* 1L (J.D.G.)
Black Pool, 7.VIII.40, ex *Tamiasciurus hudsonicus streatori,* 1♀ (J.D.G.)
Rayleigh, 9.II.41, ex *Tamiasciurus hudsonicus streatori,* (*nest*) 5♂, 4♀, N, L (J.D.G.)
Kamloops, 11.VIII.29, ex *Tamiasciurus hudsonicus streatori,* 1♀, 15N, 1L (I.McT.C.)
Monte Cr., 6.VII.29, ex *Tamiasciurus hudsonicus streatori,* 5♀, 34N, 10L (I.McT.C.)
Nicola, 13.V.33, ex *Tamiasciurus hudsonicus streatori,* 3L (T.K.M.)
Deadman Cr., 26.VIII.33, ex *Tamiasciurus hudsonicus streatori,* 4N, 1L (D.C.)
Shumway L., 28.I.41, ex *Tamiasciurus hudsonicus streatori,* 1♀ (G.P.H.)
Ewings Ldg., 18.X.46, ex *Tamiasciurus hudsonicus streatori,* 1♀ (J.D.G.)

IXODES AURITULUS Neumann

Figs. 139, 140, 141, 142, 143, 144, 145, 146; Map III

Ixodes auritulus Neumann, 1904, p. 450.
Ixodes auritulus, Nuttall *et al.,* 1911, p. 187.
Ixodes auritulus, Hewitt, 1915, p. 227.
Ixodes auritulus, Hearle, 1938, p. 350.
Ixodes auritulus, Cooley and Kohls, 1945, pp. 195-200.
Ixodes auritulus, Bequaert, 1946, p. 143.
Ixodes percavatus, Zumpt, 1952 (*nec* Neumann, 1906), pp. 12-20.
Ixodes percavatus var. *rothschildi,* Arthur, 1953 (*nec* Nuttall *et al.,* 1911), pp. 222-226.
Ixodes auritulus, Dumbleton, 1953, pp. 9-10.

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This distinctive species has a remarkably wide distribution, and occurs on passerine and gallinaceous birds from the most southerly tip of South America north at least to the Queen Charlotte Islands, B.C. In Canada it appears to be confined mainly to the Pacific coast, where it replaces *H. chordeilis* as the common parasite on grouse.

The female of *I. auritulus* is readily recognized by the inner and anteriorly directed spur on palpal article I. The auriculae are heavy and hornlike. Both these characters show in the nymphal stage.

Canadian records

B.C. Tofino, 28.V.31, ex grouse, 1♀, 2N (K.R.)
Victoria, 25.VII.32, ex sparrow, 24N (J.A.M.)
Sidney, 2.XI.35, ex *Junco* sp., 1♀ (——)
Queen Charlotte Is., -.VI.30, ex *Cyanocitta stelleri,* 1N (C.C.)
Queen Charlotte Is., 17.VI.10, ex *Cyanocitta stelleri,* —— (S.H.)
Queen Charlotte Is., 5.VII.39, ex *Corvus brachyrhynchos,* 1N (——)
West Vancouver, 8.VIII.34, ex grouse, 5N, 1L (J.D.G.)
Vavenby, 16.IV.40, ex *Ixoreus naevius,* 1L (J.D.G.)
Ont. Timagami, -.-.-., ex *Microtus* sp., 1N (Bequaert 1946)

IXODES MARXI Banks

Figs. 92, 93, 94, 95, 96, 97, 98, 99, 100, 101; Map VII
Ixodes marxi Banks, 1908a, p. 32.
Ixodes marxi, Nuttall *et al.,* 1911, pp. 173-174.
Ixodes marxi, Hewitt, 1915, p. 228.
Ixodes marxi, Cooley and Kohls, 1945, pp. 125-129.
Ixodes marxi, Bequaert, 1946, pp. 158-159.

This is the "squirrel tick" of the east, although from records it apparently also attaches to rabbits. The slight differences between this species and *hearlei* are mentioned in the notes on the latter species.

Canadian records

Ont. Ottawa, -.V.49, ex *Sciurus carolinensis leucotis,* —— (——)
Costello L., 2.VIII.37, ex *Tamiasciurus hudsonicus loquax,* 1♀ (D.M.D.)
Batchewana, 10.VIII.35, ex domestic cat, 1N (D.M.D.)
Batchewana, 19.VIII.35, ex *Glaucomys sabrinus macrotis,* 1♀, 2N (D.M.D.)
Algoma, 19.VI.35, ex *Glaucomys* sp., 1N (C.H.D.C.)

IXODES MARMOTAE Cooley and Kohls

Figs. 175, 176, 177, 178, 179, 180, 181, 182, 183, 184; Map V
Ixodes marmotae Cooley and Kohls, 1938, pp. 2174-2181.
Ixodes marmotae, Cooley and Kohls, 1945, pp. 99-103.
Ixodes hexagonus var. *cookei,* Hearle, 1938 (in part) (*nec* Packard, 1869), p. 350.

Ixodes marmotae is the western counterpart of *cookei,* which it resembles closely. However, in *marmotae* the females usually lack lateral carinae. In nymphs, the scutum is relatively narrow, being about as broad as long in *marmotae,* and broader than long in *cookei.* The hypostome of the former is also longer and narrower than that of *cookei,* as illustrated by Cooley and Kohls (1945, p. 101) but not as described (p. 102). Nor is the posterior margin of the basis capituli necessarily sinuous.

Ixodes marmotae is found almost exclusively on *Marmota flaviventris* subspecies. It is relatively common on these animals in the British Columbia dry belt.

Canadian records

B.C. (selected from 36 collections)
Oyama, 19.V.30, ex *Marmota flaviventris avara,* 2♀, 2♂ (A.D.)
Douglas L., 16.VI.30, ex *Marmota flaviventris avara,* 2♀, 18N, 10L (T.K.M.)
Shumway L., 21.VI.33, ex *Marmota flaviventris avara,* 1N, 1L (T.K.M.)
Nicola, 27.VII.33, ex *Marmota flaviventris avara,* 1♀, 7N, 3L (T.K.M.)
Fairview, 17.VI.34, ex *Marmota flaviventris avara,* 1N (G.J.S.)
Flagstone, 15.V.40, ex *Citellus columbianus,* 1N (J.B.P.)
Hedley, 20.IV.40, ex *Marmota flaviventris avara,* 8N (J.D.G.)

IXODES SCULPTUS Neumann

Figs. 156, 157, 158, 159, 160, 161, 162, 163, 164; Map VI
Ixodes sculptus Neumann, 1904, p. 462.
Ixodes sculptus, Nuttall *et al.,* 1911, p. 171.
Ixodes sculptus, Brown, 1944, p. 49.
Ixodes sculptus, Cooley and Kohls, 1945, pp. 105-117.
Ixodes sculptus, Brown and Kohls, 1950, pp. 200-201.

I. sculptus is in the *marmotae-cookei* group. It is separated from these species by the sinuous posterior margin of the basis capituli in the female. The nymphs differ from those of *marmotae* in having a shorter hypostome, and from *cookei* in that the anterior horn on palpal article I is longer. It is a common parasite of prairie ground squirrels and their predators, the weasels and badgers.

In Canada it is found in the Great Plains area and the southeast corner of British Columbia.

Canadian records

B.C. Kimberley, 11.V.38, ex *Citellus c. columbianus,* 5♀ (J.B.P.)
Kimberley, 13.IV.41, ex *Citellus c. columbianus,* N (J.B.P.)
Elko, 5.VII.41, ex *Citellus c. columbianus,* 1♀ (J.B.P.)
Elk R., 5.VII.41, ex *Citellus c. columbianus,* 1♀ (J.B.P.)
Phoenix, 2.V.41, ex rabbit, 1♀ (J.B.P.)

Alta. (selected from 40 collections)
Aden, 1.X.40, ex weasel, N (J.G.)
Stanmore, 14.X.39, ex *Citellus richardsoni,* 1♀, 1N (J.H.B.)
Cereal, 11.VI.41, ex *Citellus richardsoni,* 2♀ (J.H.B.)
Hanna, 11.VII.42, ex *Citellus richardsoni,* 1♂, N (J.H.B.)
Bassano, 1.VII.42, ex *Citellus richardsoni,* ♀♀, LL (J.H.B.)
St. Kilda, 15.VIII.51, ex *Thomomys talpoides* ssp., 8N, 1L (J.E.M.)

Sask. Val Marie, 8.VII.42, ex weasel, 1♀ (G.P.H.)
Estevan, 4.VIII.42, ex *Mustela frenata longicauda,* ♀♀, NN (G.P.H.)
Regina, 11.X.33, ex rabbit, 2♀, 5L (——)
Swift Current, 6.VII.50, ex *Citellus richardsoni,* 3♀, 4N (G.D.B.)
Rosetown, -.-.-., ex *Citellus richardsoni,* (not seen) (G.D.B.)
Oxbow, -.-.-., ex *Citellus richardsoni,* (not seen) (G.D.B.)

IXODES KINGI Bishopp

Figs. 195, 196, 197, 198, 199, 200, 201, 202, 203, 204; Map VI
Ixodes pratti, Banks 1908a (in part), p. 27.
Ixodes pratti, Nuttall *et al.,* 1911 (*nec* Banks, 1908a), p. 174.
Ixodes pratti, Hadwen, 1913 (*nec* Banks, 1908a).
Ixodes kingi Bishopp, 1911, p. 201.
Ixodes kingi, Hearle, 1938, p. 250.
Ixodes kingi, Cooley and Kohls, 1945, pp. 131-137.
Ixodes kingi, Brown, 1944, p. 49.
Ixodes pratti, Brown, 1944 (*nec* Banks, 1908a), p. 49.
Ixodes marmoti [sic], Brown, 1944 (*nec* Cooley and Kohls, 1945), p. 49.
Ixodes kingi, Brown and Kohls, 1950, p. 200.

The synonomy of *Ixodes pratti* with *I. kingi,* as explained by Cooley and Kohls (1945, pp. 132-134), is due to the fact that although part of Banks' material included specimens of what was later described as *kingi* by Bishopp, the type specimens (designated by him, or Bishopp) were of other species (*scapularis* Say, 1821, and *texanus* Banks, 1908b). Cooley and Kohls thus made *pratti* a synonym of *scapularis.*

Ixodes kingi and *I. sculptus* are the two common prairie *Ixodes.* Both are frequently found on prairie ground squirrels and their predators, the weasels and badgers. *I. kingi* is also occasionally found on dogs. This tick, though resembling *sculptus,* is more massive in structure, having broader and more rugged palps and an exceptionally stout hypostome on which the teeth are blunt and conical. The fully engorged female is remarkably spherical.

50988—4½

Canadian records

Alta. Milk River, -.VII.11, ex dog, 1♀ (A.W.)
Milk River, -.VII 11, ex cat, 1♀ (A.W.)
Medicine Hat, 10.IV.32, ex *Citellus richardsoni,* 1♀, 1♂ (F.S.C.)
Delia, -.V.32, ex dog, 1♀ (F.S.C.)
Aden, -.XI.40, ex weasel, 1♀, 1N (F.S.C.)
Suffield, 20.VII.42, ex weasel, 1♀ (J.H.B.)
Suffield, -.IX.44, ex *Taxidea taxus* ssp., 2♂, 2♀ (H.H.)
Suffield, 20.IV.43, ex dog, 1♀ (H.H.)
Crows Nest Pass, 2.VIII.48, ex *Taxidea taxus* ssp., 1♀, 3♂ (——)
Suffield, 1.VI.43, ex dog, 1♀ (——)
Foremost, 12.VIII.51, ex *Lemmiscus curtatus pallidus,* 1N (J.E.M.)

Sask. Estevan, 20.VII.42, ex weasels, ♀♀ (G.P.H.)

IXODES COOKEI Packard

Figs. 165, 166, 167, 168, 169, 170, 171, 172, 173, 174: Map VII
Ixodes cookei Packard, 1869, p. 67.
Ixodes hexagonus var. *cookei,* Nuttall *et al.,* 1911, p. 183.
Ixodes cookei, Cooley and Kohls, 1945, pp. 91-97.
Ixodes cookei, Bequaert, 1946, pp. 151-158.

This is a common eastern tick that, in hosts and morphology, closely resembles the European species *I. hexagonus.* It is partial to medium-sized mammals, particularly the Carnivora, but has been taken also from marmot, beaver*, porcupine, cow, and owl in Canada. It often attacks man, leaving painful and slow-healing sores in the manner of *I. pacificus.*

I. cookei resembles both *marmotae* and *sculptus* but can be recognized by differences of the scutum, hypostome, and palps (see notes on these species). As in other instances where the differences between species are slight and comparative, host and locality records offer the main clues to their separation.

Canadian records

Man. Winnipeg, ——, ex dog, 4N (J.M.I.)

Ont. Westboro, 23.VII.41, ex dog, 2♀ (L.L.B.)
Northwood, 7.VII.40, ex dog, —— (——)
Ottawa, 7.VII.49, ex child, 1N
Apple Hill, -.VII.47, ex man, —— (——)
Kawene, -.XI.45, ex *Marmota* sp., ——(A.C.B.)
Toronto, 13.VII.51, ex dog, 1♀ (D.M.D.)
Cache L., 8.VIII.50, ex *Martes s. americana,* 1♀ (D.M.D.)
Cache L., 9.VIII.50, ex *Martes p. pennanti,* 1♀ (D.M.D.)
Byron, 29.III.30, ex *Marmota monax,* 1N (E.D.)
Algonquin Pk., 12.XII.50, ex *Mustela v. vison,* 1♀ (E.D.)
Sasajewan L., 22.VI.50, ex *Mephitis m. nigra,* 1♀ (E.D.)
*Sasajewan L., 10.VIII.50, ex *Castor c. canadensis,* 6N (E.D.)
Traverse L., 12.VII.36, ex *Erethizon d. dorsatum,* 2♀ (E.D.)
Brampton, 28.XII.49, ex *Procyon l. lotor,* 1N (E.D.)
Buckshot L., 27.VII.32, ex *Mephitis m. nigra,* 11N (E.D.)
Batchewana, 4.IX.35, ex *Mephitis m. nigra,* 1♀ (E.D.)
*Sudbury Dist., 4.IV.49, ex *Castor c. canadensis,* 3N (E.D.)
Campbellville, 26.VI.47, ex *Marmota monax rufescens,* —— (Judd 1950)

Que. Hemmingford, 19.VII.35, ex dog, 5♀ (A.L.S.)
St. Lambert, -.VIII.39, ——, 1N (C.N.C.)
Cascades, 27.VIII.38, ex man, 1♀ (——)

N.B. Fredericton, -.VIII.41, ex *Mephitis mephitis* ssp., 1♀ (——)
Enniskillen, 29.V.45, ex child, ♀ (——)
Petitcodiac, 24.IV.41, ex cow, 1N (E.T.)

N.S. Shelburn Co., 20.VIII.38, ex *Mustela vision* ssp., 1♀ (——)

P.E.I. Charlottetown, 30.IX.47, ex dog, —— (C.I.P. Rev. #25)

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*Since going to press, correspondence with G. M. Kohls has revealed that the ticks from these two collections are of *Ixodes banksi* Bishopp. The female tick from *Castor canadensis,* Arden Lake, Sudbury Dist., May 11, 1953 (see Judd, W. W., 1954. J. Parasit. 40: 483) is likewise *Ixodes banksi* Bishopp.

IXODES MURIS Bishopp and Smith

Figs. 147, 148, 149, 150, 151, 152, 153, 154, 155; Map VII
Ixodes muris Bishopp and Smith, 1937, pp. 133-138.
Ixodes muris, Cooley and Kohls, 1945, pp. 145-148.
Ixodes muris, Bequaert, 1946, pp. 147-148.

This tick has been taken on small rodents in Nova Scotia and Labrador. It is a common parasite of mice in the northeastern United States and has been recorded once from Utah on muskrats (Kohls, 1952). It is known also to attack small migratory birds. Considering the northerly occurrence of the following record it would not be surprising to find this tick in Ontario and Quebec. Canadian specimens have not been examined by the writer.

Canadian records

N.S. Lake Kedgemacooge, ——, ex *Napaeozapus i. insignis,* (Bequaert, 1946)

IXODES SIGNATUS Birula

Figs. 65, 66, 67, 68, 69, 70, 71, 72, 73; Map III
Ixodes signatus Birula, 1895, pp. 357-358.
Ixodes signatus, Nuttall *et al.,* 1911, pp. 261-264.
Ixodes signatus, Hearle, 1938, p. 352.
Ixodes signatus, Cooley and Kohls, 1945, pp. 201-203.
Ixodes signatus, Zumpt, 1952, pp. 17-18.
Ixodes signatus, Gregson, 1954, pp. 275-277.

This species is restricted mainly to marine birds, of which the cormorant appears to be the favored host. An exception is a record in the files of the Kamloops laboratory of three females and one nymph from *Leucosticte* sp. (rosy finch) from the Pribiloff Islands, collected 10.VII.49 by Dr. G. C. Carl. *I. signatus* has a wide distribution, having been taken in California, the Aleutian Islands, and Japan. It is a large species and is recognizable by the broad, rounded auriculae and the absence of internal coxal spurs. Engorged specimens are elongate in appearance. The males of this and the following species are characterized by their poorly armed hypostomes and the extensions of palpal articles 3 beyond 4.

Canadian records

B.C. Tofino, 5.VIII. 26, ex *Phalacrocorax* sp., 2♀, 22N (G.J.S.)
Gull Island (Howe Sound), 4.VII.39, ex *Phalacrocorax* sp., 4N, 1L (J.D.G. & G.P.H.)
Cowichan Bay, 25.I.41, ex *Phalacrocorax* sp., 1♀L (I.McT. C.)
Langara Is., Q.C.I., 8 VI. 46, ex *Phalacrocorax* sp., 3♀ (G.C.C.)

IXODES URIAE White

Figs. 56, 57, 58, 59, 60, 61, 62, 63, 64; Map III
Ixodes uriae White, 1852, p. 210.
Ixodes putus, Nuttall *et al.,* 1911 (*nec* Pickard-Cambridge, 1878), p. 256.
Ixodes putus, Hearle, 1938 (*nec* Pickard-Cambridge, 1878), p. 222.
Ixodes uriae, Cooley and Kohls, 1945, pp. 223-227.
Ixodes uriae, Bequaert, 1946, pp. 140-141.
Ceratixodes uriae, Zumpt, 1952, pp. 12-15.

This species has a cosmopolitan distribution, occurring in Europe, Asia, Australia, and America. In Canada it has been taken on the Atlantic and Pacific coasts. Like the preceding species, which it resembles by its lack of internal coxal spurs, this tick is a parasite of marine birds.

The females are distinguished by their hairiness, the males by an unusual terminal fringe of spines. Because of the poorly armed nature of their hypostomes, it is believed that the males of both this and the preceding species are nest inhabitants and do not feed.

Canadian records

B.C. Tofino, 14.VIII.26, ex seagull, 1 ♀, 1N,1L (G.J.S.)
Langara Is., Q.C.I., 8.VI.46, ex *Phalacrocorax* sp., 1 ♀ (G.C.C.)

N.S. Bird Is., Cape Breton, 27.VI.33, *ex Fratercula arctica,* 1 ♀ (Bequaert, 1946)
Great Bird Rock, G. St. Lawrence, 1.VII.81, *Uria aalge,* 1N (Bequaert, 1946)
Bay of Fundy,—, *Alca torda,* 1 ♀, (Bequaert, 1946)

IXODES BANKSI Bishopp

Figs. 205, 206, 207, 208, 209, 210, 211, 212, 213.
Ixodes banksi, Bishopp, 1911, pp. 200-201.
Ixodes banksi, Cooley and Kohls, 1945, pp. 167-170.
Ixodes cookei, Judd, W. W., 1954, J. Parasit. 40: 483 (*nec* Packard).

Ixodes banksi was first described from a series of females taken from muskrat (*"Fiber zibethicus"* Linn. (=*Ondatra zibethicus* (Linn.))) in Arkansas. It is closely related to *I. cookei* but may be separated from this species by the larger spiracular plates. Bishopp (1911) gives the dimensions of those of *cookei* females as varying from 0·33 to 0·46 mm. x 0·28 to 0·41 mm., whereas those from his *banksi* measured from 0·50 to 0·56 mm. x 0·45 to 0·50 mm. Cooley and Kohls cite the length of the spiracular plate of a *cookei* nymph as 0·14 mm. That of a nymph of *banksi* examined by the author was 0·19 mm.

I. banksi also differs from *cookei* in that its cornua and tarsal humps are less pronounced, and its internal coxal spurs are slightly shorter. The spurs on palpal article I of the nymph are also more reduced than those of *cookei.*

Nevertheless, the two species are sufficiently similar to be confused, and ticks taken from coyotes and skunks in Oklahoma and placed (with reservation) under *banksi* by Cooley and Kohls (1945), and others taken from beaver in Canada and identified as *cookei,* have now had their identity reversed (G. M. Kohls, in litt.). Fortunately, a host specificity of *banksi* to beavers and muskrats now appears to exist, and this should aid in alerting the taxonomist to its identity.

Canadian records

Ont. Sasajewan L., 10.VIII 50, ex *Castor c. canadensis,* 6N (E.D.)
Sudbury Dist., 4.IV.49, ex *Castor c. canadensis,* 3N (E.D.)
Arden L., Sudbury Dist., 11.V.53, ex *Castor canadensis,* 1 ♀ (Judd, W. W., 1954. Jour. Parasit. 40: 483)

OTHER SPECIES LIKELY TO OCCUR IN CANADA

It is possible that species of ticks that occur naturally in areas of the United States bordering Canada are already present in this country. These include *I. dentatus* Marx, which has been found on rabbits (*Sylvilagus* sp.) in the Adams, Dauphin and Westmoreland counties of Pennsylvania; *I. scapularis* Say, which has been recorded from mice (*Microtus* and *Peromyscus* spp.) from Cape Cod, Mass.; *I. brunneus* Koch, a parasite of passerine birds, from Baltimore, Md.; *O. parkeri* Cooley, a frequent inhabitant of nests of burrowing owls (*Speotyto* sp.) and ground squirrels (*Citellus* sp.) in Washington, Idaho, and Montana; and *O. kelleyi* Cooley and Kohls, a bat parasite, recorded from such northerly localities as Niagara County, N.Y., and central Minnesota.*

Other neighbouring species, not yet present in Canada, may be introduced through the agency of hosts. These hosts may be either domestic or game animals moved by man, or natural migrants. There is little doubt that the introduction of the brown dog tick, *R. sanguineus,* into Canada was brought about by such means. Possibilities in this category include *D. occidentalis*

*Since going to press, *O. kelleyi* has been taken (20.IV.54) from a bat-occupied building at Saskatoon, Saskatchewan.

Marx, which occurs on cattle, horses, man, and a large variety of other hosts, along the Pacific coast north to Yachats, Oreg.; *D. parumapertus* Neumann, which has been recorded from deer (*Odocoileus* sp.), coyotes (*Canis* sp.), and man, but mainly from rabbits (*Lepus and Sylvilagus* spp.), and taken as far north as Burns, east-central Oregon, and Grandview, Idaho. The migrating hosts are birds and bats, and it is possible that ticks feeding on these may be transported from regions even farther south than the above-listed species. *I. baergi* Cooley and Kohls, collected from cliff swallows (*Petrochelidon* sp.) in Arkansas, is an example. Bat-infesting argasids of North America include *O. concanensis* Cooley and Kohls, *O. dyeri* Cooley and Kohls, *O. hermsi* Wheeler, Herms, and Meyer, *O. kelleyi* Cooley and Kohls, *O. stageri* Cooley and Kohls, *O. yumatensis* Cooley and Kohls, and *Antricola coprophilus* (McIntosh). Spencer (1940) recorded three soft ticks from a bat later identified by Cowan (1945) as *Tadarida macrotis* (Gray), but it has been impossible to determine either the nature or the whereabouts of these specimens. It is doubtful whether any of the southern species of the above group would establish themselves in Canada even if introduced.* This would apply to species and genera not mentioned in this section whose early stages infest migrating birds, and may be carried north, or whose normal distribution is confined to the southern United States. The record of *Amblyomma americanum* (Linnaeus), captured on grass at Aweme, Man., by Hadwen (1912), is regarded as such an instance. According to Cooley and Kohls (1944b) it is abundant in Texas, Louisiana, Oklahoma, Arkansas and Missouri, where it infests a wide range of hosts, including birds. Bequaert (1946) states that the northern limit of its breeding range appears to lie in southern New Jersey and Pennsylvania although possibly it extended farther north formerly. The northerly records from Massachusetts, New Jersey, Pennsylvania, and Ohio by Bequaert (1946); from Ohio (Edmunds, 1954); and from Minnesota and Ohio (Riley, 1944) are all from humans. Whether some of these specimens were brought north on man is not known, but in this age of rapid travel his potentiality as a host in disseminating ticks should not be overlooked. A recent record of *Amblyomma cajennense* (Fabricius) from a man at Guelph, Ont., who imports fruits and vegetables from California is such an instance. This species is common in Mexico and southern Texas, but has been found in scattered localities further north (Cooley and Kohls, 1944b).

NOTES ON COLLECTING, REARING, AND PRESERVING

Excepting the few species that seek their hosts by placing themselves at vantage points on vegetation, ticks can be collected only from their hosts or their hosts' nests. Adults of *D. andersoni, D. variabilis, I. pacificus* come under the first group. Provided that one is in a heavily infested area at the correct time of year (spring for *Dermacentor* spp.; spring, fall, and winter for *I. pacificus*), one can collect several hundred specimens an hour by means of "dragging". This method consists of dragging over and poking among low vegetation with a square yard of white flannel attached to a stick in the manner of a flag. The ticks voluntarily transfer from their perches to the cloth, from which they may be removed to a vial containing a few blades of grass for humidity and having a cork that fits tightly enough to prevent the ticks from crawling between it and the glass. Before the cork is removed, a sharp tap on

*With the extension of the range of the muskrat and beaver tick, *I. banksi* Bishopp, from Arkansas to Canada, and the taking of large numbers of *Ornithodoros* ticks at sea level in Britain (Hobart, J., and P. E. S. Whalley, 1954, Nature 174: 936), the protection of certain southern species from adverse temperatures, by the aquatic surroundings of their hosts should perhaps be considered more carefully.

the vial causes the crawling mass to ball up and so facilitates handling. The ticks may be examined or counted on a sheet of glass (for easy removal) and stored in cotton-plugged vials in a cool and dark place, such as a root cellar.

The larvae of *D. albipictus* may be collected in a similar manner, though owing to their small size they become easily entangled in the cotton of the drag. Large clumps of the seed ticks can usually be seen at a distance and removed with the grass on which they are clustered. Larvae, nymphs and adult ticks in various stages of engorgement may be collected from birds and mammal hosts that have been shot or trapped. Although many ticks remain attached after the hosts become cold, some usually detach shortly after the latter die. For this reason it is preferable to place the individual hosts in bags as soon as they are collected. Later they are examined as for fleas (Holland, 1949).

Flat and partially fed specimens are usually dropped into 70 per cent alcohol with appropriate records of date, locality, collector, and host. If well-distended legs are particularly desired, then the live specimen is dropped into alcohol that has been brought to the verge of boiling. Since all stages of ticks are best preserved and studied in alcohol, mounting techniques are unnecessary and undesirable. Engorged immature specimens may be kept alive for rearing to the next stage; similarly, gravid females may be kept alive for oviposition.

Where possible, nesting material should be examined. Nests of squirrels and mice, and birds, particularly of species that inhabit rodent burrows, hollow trees, and bird houses, are of special importance. Because of the quiescent nature of moulting ticks, hand searching, though tedious, is the most reliable method for examining nesting material.

The laboratory rearing of ticks is somewhat difficult since it usually requires the capture and maintenance of one or more host animals. However, a rearing program is rewarding since it is frequently the only means by which data on longevity, host specificity, etc., can be accumulated. Often it provides the only way for obtaining unfed adults of both sexes that can be associated with the cast nymphal skins.

At the Kamloops laboratory live ticks are usually kept in shell vials that are tightly plugged with non-absorbent cotton and stored in one of two places. For prolonged storage, development is retarded by keeping them in a damp earthen cellar where the temperature is constantly about 50°F. Though the shorter-lived ticks may die and become moldy, healthy unfed ticks of certain species have been kept alive for many years under these conditions. If rapid metabolism is required, they are placed over a saturated solution (80 per cent relative humidity) of ammonium chloride in a desiccator jar at room temperature. Even faster development may be attained if the temperature is raised to 80°F., and under this condition the life-cycle of *D. andersoni* may be completed in less than four months.

Infesting appliances for feeding the flat ticks often have to be modified to suit the host. For mass feeding of the larvae and nymphs of most species on rodent hosts the following procedure is satisfactory. The host is first given a good feed to ensure its complacency during an ensuing fast of about 12 hours. It is then placed in a light canvas bag of ample proportions, depending on the size of the host. Two animals provided mutual comfort and greater opportunities for tick attachment than one. The ticks (the progeny of two or three females, if larvae) are shaken over the animals, after which the bag is tied securely and placed in a 10-x-10-x-12-inch infesting cage of $\frac{1}{4}$-inch hardware screen. This cage is placed in a wire rack over which is stretched a cotton infesting bag. During the first 12 hours the assembly is placed in a moist dark cellar conducive to the hosts' repose. After this period the animals are taken from the inner bag and retained in the bag-covered cage until the engorged ticks drop. This method is described more fully by Kohls (1937).

Adult ticks may be fed under a capsule that prevents the host from destroying them during the ticks' one-week feeding period. For guinea pigs and other small animals a screw-top capsule, secured to the belly by an adhesive girdle, as described by Kohls (1937), is used. At Kamloops engorging adult ticks (*D. andersoni*) are confined on lambs by dome-shaped capsules one inch wide. These containers are punched out of a sheet of 20-gauge brass screen. The rims may be dipped in solder for rigidity and then taped to prevent chafing of the host's skin. At the time of application an area on the lamb's back similar to the size of the capsule is closely clipped and washed free of grease. At six or eight opposing spots around this site the wool is gathered and slipped into clove hitches at the ends of 6-inch lengths of stout linen thread. The desired number of ticks is then placed under the capsule (with a wad of moist absorbent cotton if the weather is hot) and the capsule secured by threading half of the linen threads, each into the nearest shoulder of the cage and out the far side, and tying them to the opposing threads. In this way the anchoring threads are protected from wear and scratching. With luck, and daily attention, these cages may remain intact until the ticks have completed their feeding. If mature, long-wooled sheep are used, the wool may simply be gathered around the capsule and tightly tied together. A cement that frequently assists the anchoring of capsules on smooth-haired animals such as dogs consists of a mixture of 80 parts of resin, 15 of beeswax, and 5 of lanolin. The rim of the capsule is dipped into the hot cement and quickly applied to the host.

White mice may be used for feeding adults of *D. andersoni*. To protect the ticks the following method is satisfactory. A disk 2½ inches in diameter is cut from a thin rubber glove and reinforced at the centre with a bicycle tire patch three-quarters of an inch wide. A hole three-eights of an inch wide is then cut out of the centre with a cork borer. This collar is placed on the neck of the mouse by slipping it off the open end of an inch vial. It makes an effective barrier between the animal's head and the feeding ticks. Until the latter attach, the mouse is backed into a gauze-bottomed tube and held in by a yoke made from a bottle cap, the latter's flange fitting against the rim of the tube where it is held, by two nails, in a rack. A rubber bank temporarily secures the collar lightly around the rim of the vial.

The argasid ticks, which are rapid feeders, are less of a problem since the host need only be confined for an hour or so. Mice are usually slipped into a cylinder of ¼-inch screen, through which the ticks are fed while under observation. Avid feeders attach readily and engorge rapidly. Pressure by the finger, and darkness, often promote attachment; some ticks may refuse to feed week after week.

All in all, the experimental feeding of ticks offers many difficulties, and it is soon discovered that one's patience and resourcefulness are too often more than matched by the opposing craftiness of the host animal.

HOST-TICK INDEX

The following index pertains only to Canadian records. In it are listed the selected records in the text and other host records, new or published, up to December 31, 1953. With the exception of *Dermacentor andersoni, D. variabilis,* and *Ixodes pacificus,* the adults and early stages of which confine themselves mainly to large and small animals respectively, it is assumed that all instars of the species listed feed on the specified hosts. Even the above species exhibit marked exceptions, such as the readiness with which adults of *D. andersoni* engorge on laboratory mice, and records of nymphs of *variabilis*

attacking man. Exceptions such as these, together with those shown by ticks normally tending to be host-specific, suggest that the range of hosts for any one species may be much broader than shown.

Class Reptilia

ORDER LACERTILIA, lizards

Family Anguidae

Northern alligator lizard, *Gerrhonotus coeruleus principis* (Baird and Girard)
Ixodes pacificus Cooley and Kohls

Class Mammalia

ORDER INSECTIVORA, insectivores

Family Talpidae

Scheffer's mole, *Scapanus orarius schefferi* Jackson
Ixodes pacificus Cooley and Kohls
Ixodes angustus Neumann

Hairy-tailed mole, *Parascalops breweri* (Bachman)
Ixodes angustus Neumann

Family Soricidae

Vagrant shrew, *Sorex vagrans* ssp.
Ixodes soricis Gregson

Cinereus shrew, *Sorex cinereus* ssp.
Ixodes soricis Gregson

Dusky shrew, *Sorex obscurus* ssp.
Ixodes soricis Gregson

Shrews, *Sorex* spp.
Ixodes pacificus Cooley and Kohls
Ixodes spinipalpis Hadwen and Nuttall
Ixodes angustus Neumann
Ixodes soricis Gregson

Short-tailed shrew, *Blarina brevicauda talpoides* (Gapper)
Ixodes angustus Neumann

ORDER CHIROPTERA, bats

Family Vespertilionidae

Bats (genus unknown) (or mice)
Ornithodoros hermsi Wheeler, Herms, and Meyer

Family Molossidae

Free-tailed bat, *Tadarida macrotis* (Gray)
Argasidae (specimens not examined)

ORDER PRIMATES, primates

Family Hominidae

Man, *Homo sapiens* ssp.
Ornithodoros hermsi Wheeler, Herms, and Meyer
Dermacentor andersoni Stiles
Dermacentor albipictus (Packard)
Dermacentor variabilis (Say)
Haemaphysalis leporis-palustris (Packard)
Haemaphysalis chordeilis (Packard)
Ixodes pacificus Cooley and Kohls
Ixodes spinipalpis Hadwen and Nuttall
Ixodes angustus Neumann
Ixodes cookei Packard

ORDER CARNIVORA, carnivores

Family Procyonidae

Pacific raccoon, *Procyon lotor pacifica* Merriam
Ixodes texanus Banks

Eastern raccoon, *Procyon l. lotor* (Linnaeus)
Ixodes texanus Banks
Ixodes cookei Packard

Family Ursidae

Bear, *Ursus* sp.
- *Dermacentor andersoni* Stiles
- *Dermacentor albipictus* (Packard)

Family Canidae

Mountain coyote, *Canis latrans* ssp.
- *Dermacentor andersoni* Stiles
- *Dermacentor albipictus* (Packard)
- *Ixodes rugosus* Bishopp

Wolf, *Canis lupus* ssp.
- *Dermacentor albipictus* (Packard)

Domestic dog, *Canis familiaris*
- *Dermacentor andersoni* Stiles
- *Dermacentor variabilis* (Say)
- *Rhipicephalus sanguineus* (Latreille)
- *Ixodes pacificus* Cooley and Kohls
- *Ixodes angustus* Neumann
- *Ixodes texanus* Banks
- *Ixodes cookei* Packard
- *Ixodes kingi* Bishopp

Family Felidae

Domestic cat, *Felis domestica*
- *Otobius megnini* (Dugès)
- *Otobius lagophilus* Cooley and Kohls
- *Dermacentor andersoni* Stiles
- *Haemaphysalis leporis-palustris* (Packard)
- *Ixodes pacificus* Cooley and Kohls
- *Ixodes marxi* Banks
- *Ixodes cookei* Packard
- *Ixodes kingi* Bishopp
- *Ixodes angustus* Neumann

Family Mustelidae

Pine marten, *Martes a. americana* (Turton)
- *Ixodes cookei* Packard

Fisher, *Martes p. pennanti* (Erxleben)
- *Ixodes cookei* Packard

Prairie long-tailed weasel, *Mustela frenata longicauda* Bonaparte
- *Ixodes sculptus* Neumann

Weasels, *Mustela* spp.
- *Ixodes texanus* Banks
- *Ixodes kingi* Bishopp
- *Ixodes sculptus* Neumann

Mink, *Mustela vison* ssp.
- *Ixodes pacificus* Cooley and Kohls
- *Ixodes texanus* Banks
- *Ixodes cookei* Packard

Puget Sound spotted skunk, *Spilogale phenax olympica* (Elliot)
- *Ixodes rugosus* Bishopp

Eastern striped skunk, *Mephitis m. nigra* (Peale and Beauvois)
- *Ixodes cookei* Packard

Badger, *Taxidea taxus* ssp.
- *Dermacentor andersoni* Stiles
- *Ixodes kingi* Bishopp
- *Ixodes sculptus* Neumann

ORDER LAGOMORPHA

Suborder DUPLIDENTATA

Family Ochotonidae

Pikas, *Ochotona princeps* ssp.
- *Dermacentor andersoni* Stiles
- *Ixodes spinipalpis* Hadwen and Nuttall
- *Ixodes angustus* Neumann
- *Ixodes ochotonae* Gregson

Family Leporidae

White-tailed jack rabbit, *Lepus townsendii campanius* Hollister
- *Otobius lagophilus* Cooley and Kohls
- *Dermacentor andersoni* Stiles
- *Haemaphysalis leporis-palustris* (Packard)
- *Ixodes sculptus* Neumann

Snowshoe rabbit, *Lepus americanus* ssp.
- *Haemaphysalis leporis-palustris* (Packard)
- *Ixodes marxi* Banks

Rabbits, *Lepus* sp.
- *Ixodes spinipalpis* Hadwen and Nuttall
- *Ixodes angustus* Neumann

Blackhills cottontail, *Sylvilagus nuttallii grangeri* (Allen)
- *Haemaphysalis leporis-palustris* (Packard)

Rabbits (genus unknown)
- *Haemaphysalis leporis-palustris* (Packard)
- *Ixodes sculptus* Neumann

ORDER RODENTIA

Family Sciuridae

Pallid yellow-bellied marmot, *Marmota flaviventris avara* (Bangs)
- *Dermacentor andersoni* Stiles
- *Haemaphysalis leporis-palustris* (Packard)
- *Haemaphysalis chordeilis* (Packard)
- *Ixodes texanus* Banks
- *Ixodes marmotae* Cooley and Kohls

Woodchucks, *Marmota monax* ssp.
- *Ixodes cookei* Packard

Richardson's ground squirrel, *Citellus r. richardsoni* (Sabine)
- *Dermacentor andersoni* Stiles
- *Haemaphysalis leporis-palustris* (Packard)
- *Ixodes kingi* Bishopp
- *Ixodes sculptus* Neumann

Columbian ground squirrel, *Citellus c. columbianus* (Ord)
- *Dermacentor andersoni* Stiles
- *Ixodes marmotae* Cooley and Kohls
- *Ixodes sculptus* Neumann

Franklin's ground squirrel, *Citellus franklini* (Sabine)
- *Ixodes sculptus* Neumann

Hollister's mantled ground squirrel, *Citellus lateralis tescorum* Hollister
- *Dermacentor andersoni* Stiles

Striped ground squirrel, *Citellus tridecemlineatus* ssp.
- *Ixodes sculptus* Neumann

Black-tailed prairie-dog, *Cynomys l. ludovicianus* (Ord)
- *Dermacentor andersoni* Stiles

Northeastern chipmunk, *Tamias striatus lysteri* (Richardson)
- *Ixodes angustus* Neumann

Lake Superior chipmunk, *Eutamias minimus neglectus* (Allen)
- *Ixodes angustus* Neumann

Chipmunks, *Eutamias* sp.
- *Dermacentor andersoni* Stiles
- *Haemaphysalis leporis-palustris* (Packard)
- *Ixodes pacificus* Cooley and Kohls
- *Ixodes spinipalpis* Hadwen and Nuttall
- *Ixodes angustus* Neumann

Southern red squirrel, *Tamiasciurus hudsonicus loquax* (Bangs)
- *Haemaphysalis leporis-palustris* (Packard)
- *Ixodes angustus* Neumann
- *Ixodes marxi* Bishopp

Streator's red squirrel, *Tamiasciurus hudsonicus streatori* Allen
- *Haemaphysalis chordeilis* (Packard)
- *Ixodes hearlei* Gregson

Vancouver red squirrel, *Tamiasciurus hudsonicus vancouverensis* Allen
- *Ixodes angustus* Neumann

Northwestern red-bellied squirrel, *Tamiasciurus douglasii mollipilosus* Audubon and Bachman
- *Ixodes angustus* Neumann

Tree squirrels, *Tamiasciurus* spp.
Dermacentor andersoni Stiles
Haemaphysalis leporis-palustris (Packard)
Haemaphysalis chordeilis (Packard)
Ixodes pacificus Cooley and Kohls
Ixodes angustus Neumann
Ixodes texanus Banks
Northeastern Gray squirrel, *Sciurus carolinensis leucotis* (Gapper)
Ixodes marxi Banks
Flying squirrel, *Glaucomys sabrinus* ssp.
Ixodes angustus Neumann
Ixodes marxi Banks

Family Castoridae

Canada beaver, *Castor c. canadensis* Kuhl
Ixodes banksi Bishopp

Family Geomyidae

Pocket gopher, *Thomomys talpoides* ssp.
Ixodes sculptus Neumann

Family Cricetidae

Dusky harvest mouse, *Reithrodontomys megalotis nigrescens* Howell
Ixodes spinipalpis Hadwen and Nuttall
White-footed mice, *Peromyscus maniculatus* ssp.
Dermacentor andersoni Stiles
Dermacentor albipictus (Packard)
Ixodes pacificus Cooley and Kohls
Ixodes angustus Neumann
Ixodes ochotonae Gregson
Ixodes spinipalpis Hadwen and Nuttall
Northern deer mouse, *Peromyscus leucopus novaboracensis* (Fischer)
Ixodes angustus Neumann
Western bushy-tailed woodrat, *Neotoma cinerea occidentalis* (Baird)
Dermacentor andersoni Stiles
Ixodes spinipalpis Hadwen and Nuttall
Ixodes angustus Neumann
Ixodes ochotonae Gregson
Ixodes marmotae Cooley and Kohls
Cooper's lemming mouse, *Synaptomys c. cooperi* Baird
Ixodes angustus Neumann
Red backed mice, *Clethrionomys* sp.
Ixodes angustus Neumann
Drummond's meadow mouse, *Microtus pennsylvanicus drummondi* (Audubon and Bachman)
Ixodes angustus Neumann
Meadow mice, *Microtus* sp.
Dermacentor andersoni Stiles
Dermacentor variabilis (Say)
Ixodes angustus Neumann
Ixodes ochotonae Gregson
Ixodes auritulus Neumann
Pallid pigmy vole, *Lemmiscus curtatus pallidus* (Merriam)
Ixodes kingi Bishopp
Mouse (genus unknown) (or bat)
Ornithodoros hermsi Wheeler, Herms, and Meyer

Family Muridae

Rat, *Rattus* sp.
Ixodes angustus Neumann
Ixodes spinipalpis Hadwen and Nuttall

Family Zapodidae

Saskatchewan jumping mouse, *Zapus princeps minor* Preble
Dermacentor andersoni Stiles
Jumping mouse, *Zapus* sp.
Ixodes angustus Neumann
Eastern woodland jumping mouse, *Napaeozapus i. insignis* (Miller)
Ixodes muris Bishopp and Smith

Family Erethizontidae

Eastern Canada porcupine, *Erethizon d. dorsatum* (Linnaeus)
Ixodes cookei Packard

Porcupines, *Erethizon* sp.
Dermacentor andersoni Stiles

ORDER ARTIODACTYLA, even-toed hoofed animals

Family Cervidae

Rocky Mountain mule deer, *Odocoileus h. hemionus* (Rafinesque)
Otobius megnini (Dugès)
Dermacentor andersoni Stiles
Dermacentor albipictus (Packard)

Columbian black-tailed deer, *Odocoileus hemionus columbianus* (Richardson)
Dermacentor albipictus (Packard)
Ixodes pacificus Cooley and Kohls

Rocky Mountain elk, *Cervus canadensis nelsoni* Bailey
Dermacentor albipictus (Packard)

Family Bovidae

Montana mountain goat, *Oreamnos americanus missoulae* (Allen)
Otobius megnini (Dugès)
Dermacentor andersoni Stiles

Rocky Mountain bighorn, *Ovis c. canadensis* Shaw
Otobius megnini (Dugès)
Dermacentor andersoni Stiles

Domestic sheep
Dermacentor andersoni Stiles
Dermacentor variabilis (Say)
Ixodes pacificus Cooley and Kohls

Domestic goat
Dermacentor andersoni Stiles
Ixodes pacificus Cooley and Kohls

Buffalo, *Bison b. bison* (Linnaeus)
Dermacentor albipictus (Packard)

Caribou, *Rangifer* sp.
Dermacentor albipictus (Packard)

Moose, *Alces* sp.
Dermacentor albipictus (Packard)

Cow
Dermacentor andersoni Stiles
Dermacentor albipictus (Packard)
Dermacentor variabilis (Say)
Haemaphysalis chordeilis (Packard)
Ixodes pacificus Cooley and Kohls
Ixodes cookei Packard

ORDER PERISSODACTYLA, odd-toed hoofed animals

Family Equidae

Horse
Dermacentor andersoni Stiles
Dermacentor albipictus (Packard)
Haemaphysalis chordeilis (Packard)

Class Aves

ORDER PELICANIFORMES, webbed swimmers

Cormorants, *Phalacrocorax* sp.
Ixodes signatus Birula
Ixodes uriae White

ORDER CHARADRIIFORMES, shore birds

Atlantic puffin, *Fratercula arctica* (L.)
Ixodes uriae White

Common murres, *Uria aalge* ssp.
Ixodes uriae White

Razor-billed auk, *Alca torda* L.
Ixodes uriae White

ORDER FALCONIFORMES, hawks
Bald eagle, *Haliaeetus leucocephalus* ssp.
Ixodes auritulus Neumann
Hawk (genus unknown)
Dermacentor andersoni Stiles

ORDER GALLIFORMES, gallinaceous birds
Fool hen, *Canachitis canadensis*
Haemaphysalis leporis-palustris (Packard)
Sage hen, *Centrocercus urophasianus*
Dermacentor andersoni Stiles
Sharp-tailed grouse, *Pedioectes phasianellus*
Haemaphysalis leporis-palustris (Packard)
Grouse (genus unknown)
Dermacentor andersoni Stiles
Haemphysalis leporis-palustris (Packard)
Haemaphysalis chordeilis (Packard)
Ixodes pacificus Cooley and Khols
Ixodes auritulus Neumann
Pheasant
Haemaphysalis leporis-palustris (Packard)
Haemaphysalis chordeilis (Packard)
Domestic turkey
Haemaphysalis leporis-palustris (Packard)
Haemaphysalis chordeilis (Packard)
Domestic hen
Haemaphysalis chordeilis (Packard)
Prairie chicken, *Tympanuchus* sp.
Haemaphysalis chordeilis (Packard)

ORDER STRIGIFORMES, owls
Snowy owl, *Nyctea nyctea* (L.)
Ixodes cookei Packard
Owl, *Strix* sp.
Haemaphysalis leporis-palustris (Packard)

ORDER PICIFORMES, woodpeckers
Woodpecker (genus unknown)
Haemaphysalis leporis-palustris (Packard)

ORDER PASSERIFORMES, perching birds
Steller's jay, *Cyanocitta stelleri* (Gmelin)
Ixodes auritulus Neumann
Raven, *Corvus corax*
Haemaphysalis leporis-palustris (Packard)
Crow, *Corvus brachyrhynchos* Brehm
Haemaphysalis leporis-palustris (Packard)
Ixodes auritulus Neumann
Magpie, *Pica pica*
Haemaphysalis leporis-palustris (Packard)
Tree creeper, *Certhia familiaris* ssp.
Ixodes auritulus Neumann
Canyon wren, *Catherpes mexicanus* ssp.
Haemaphysalis leporis-palustris (Packard)
Hermit thrush, *Hylocichla guttata* ssp.
Ixodes spinipalpis Hadwen and Nuttall
Varied thrush, *Ixoreus naevius* ssp.
Ixodes spinipalpis Hadwen and Nuttall
Ixodes auritulus Neumann
Bluebird, *Sialia* sp.
Ornithodoros hermsi Wheeler, Herms, and Meyer
Argas reflexus (Fabricius)
Warbler (genus unknown)
Haemaphysalis leporis-palustris (Packard)
Rosy finch, *Leucosticte tephrocotis* ssp.
Ixodes signatus Birula
Junco, *Junco* sp.
Ixodes auritulus Neumann

Golden-crowned sparrow, *Zonotrichia coronata* (Pallas)
Argas persicus (Oken)
Ixodes auritulus Neumann
Haemaphysalis leporis-palustris (Packard)
Ixodes spinipalpis Hadwen and Nuttall

Puget Sound sparrow, *Zonotrichia leucophrys pugetensis* Grinnell
Haemaphysalis leporis-palustris (Packard)

By drag and clothing
Dermacentor andersoni Stiles
Dermacentor albipictus (Packard)
Dermacentor variabilis (Say)
Haemaphysalis chordeilis (Packard)
Ixodes pacificus Cooley and Kohls
Ixodes spinipalpis Hadwen and Nuttall

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Argas reflexus (Fabricius)
Bluebird, *Sialia* sp. (nest)

Argas persicus (Oken)
Golden-crowned sparrow, *Zonotrichia coronata* (Pallas)

Ornithodoros hermsi Wheeler, Herms, and Meyer
Bat, or mouse (genus unknown)
Man, *Homo sapiens* ssp.
Bluebird, *Sialia* sp. (nest)

Otobius megnini (Dugès)
Cat, *Felis domestica*
Rocky Mountain mule deer, *Odocoileus h. hemionus* (Rafinesque)
Montana mountain goat, *Oreamnos americanus missoulae* (Allen)
Rocky Mountain bighorn, *Ovis, c. canadensis* Shaw

Otobius lagophilus Cooley and Kohls
Cat, *Felis domestica*
White-tailed jack rabbit, *Lepus townsendii campanius* Hollister

Dermacentor andersoni Stiles
Man, *Homo sapiens* ssp.
Bear, *Ursus* sp.
Coyote, *Canis latrans* ssp.
Dog, *Canis familiaris*
Cat, *Felis domestica*
Badger, *Taxidea taxus* ssp.
Pika, *Ochotona princeps* ssp.
White-tailed jack rabbit, *Lepus townsendii campanius* Hollister
Pallid yellow-bellied marmot, *Marmota flaviventris avara* (Bangs)
Franklin's ground squirrel, *Citellus franklini* (Sabine)
Striped ground squirrel, *Citellus tridecemlineatus* ssp.
Richardson's ground squirrel, *Citellus richardsoni* (Sabine)
Columbian ground squirrel, *Citellus c. columbianus* (Ord)
Mantled ground squirrel, *Citellus lateralis* ssp.
Black-tailed prairie-dog, *Cynomys l. ludovicianus* (Ord)
Chipmunk, *Eutamias* sp.
Tree squirrel (genus unknown)
White-footed mouse, *Peromyscus maniculus* ssp.
Western bushy-tailed woodrat, *Neotoma cinerea occidentalis* (Baird)
Meadow mouse, *Microtus pennsylvanicus* ssp.
Pallid pygmy vole, *Lemmiscus curtatus* ssp.
Saskatchewan jumping mouse, *Zapus princeps minor* Preble
Porcupine, *Erethizon* sp.
Rocky Mountain mule deer, *Odocoileus h. hemionus* (Rafinesque)
Montana mountain goat, *Oreamnos americanus missoulae* (Allen)
Rocky Mountain bighorn, *Ovis c. canadensis* Shaw
Domestic sheep
Domestic goat
Cow
Horse
Hawk (genus unknown)
Grouse (genus unknown)
Sage hen, *Centrocercus urophasianus*
Drag or clothing

Dermacentor albipictus (Packard)
Man, *Homo sapiens* ssp.
Bear, *Ursus* sp.
Coyote, *Canis latrans* ssp.
Wolf, *Canis lupus* ssp.
White-footed mouse, *Peromyscus maniculatus* ssp.
Rocky Mountain mule deer, *Odocoileus h. hemionus* (Rafinesque)
Columbian black-tailed deer, *Odocoileus hemionus columbianus* (Richardson)
Rocky Mountain elk, *Cervus canadensis nelsoni* Bailey
Buffalo, *Bison b. bison* (Linnaeus)
Reindeer, *Rangifer* sp.
Moose, *Alces* sp.
Cow
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Drag or clothing

Dermacentor variabilis (Say)
Man, *Homo sapiens* ssp.
Dog, *Canis familiaris*
Meadow mouse, *Microtus* sp.
Domestic sheep
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Drag or clothing

Rhipicephalus sanguineus (Latreille)
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Haemaphysalis leporis-palustris (Packard)
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White-tailed jack rabbit, *Lepus townsendii campanius* Hollister
Snowshoe rabbit, *Lepus americanus* ssp.
Black Hills cottontail, *Sylvilagus nuttallii grangeri* (Allen)
Pallid yellow-bellied marmot, *Marmota flaviventris avara* (Bangs)
Richardson's ground squirrel, *Citellus richardsoni* (Sabine)
Chipmunk, *Eutamias* sp.
Southern red squirrel, *Tamiasciurus hudsonicus loquax* (Bangs)
Streator's red squirrel, *Tamiasciurus hudsonicus streatori* (Allen)
Grouse (genus unknown)
Fool hen, *Canachites canadensis*
Sharp-tailed grouse, *Pedioecetes phasianellus*
Pheasant
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Woodpecker (genus unknown)
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Crow, *Corvus brachyrhynchos*
Magpie, *Pica pica*
Canyon wren, *Catherpes mexicanus* ssp.
Warbler (genus unknown)
Golden-crowned sparrow, *Zonotrichia coronata* (Pallas)
Puget Sound sparrow, *Zonotrichia leucophrys pugetensis*

Haemaphysalis chordeilis (Packard)
Man, *Homo sapiens* ssp.
Pallid yellow-bellied marmot, *Marmota flaviventris avara* (Bangs)
Cow
Horse
Grouse (genus unknown)
Pheasant
Domestic turkey
Domestic hen
Prairie chicken, *Tympanuchus* sp.
Drag or clothing

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Northern alligator lizard, *Gerrhonotus coeruleus principis* (Baird and Girard)
Scheffer's mole, *Scapanus orarius schefferi* Jackson
Shrews, *Sorex* sp.
Man, *Homo sapiens* ssp.
Dog, *Canis familiaris*
Cat, *Felis domestica*
Mink, *Mustela vison* ssp.
Chipmunk, *Eutamias* sp.
Tree squirrel, *Tamiasciurus* spp.
White-footed mouse, *Peromyscus maniculatus* ssp.
Columbian black-tailed deer, *Odocoileus hemionus columbianus* (Richardson)

Domestic sheep
Domestic goat
Cow
Grouse (genus unknown)
Drag or clothing

Ixodes spinipalpis Hadwen and Nuttall
Shrews, *Sorex* sp.
Man, *Homo sapiens* ssp.
Pika, *Ochotona princeps* ssp.
Rabbit, *Lepus* sp.
Chipmunk, *Eutamias* sp.
Dusky harvest mouse, *Reithrodontomys megalotis nigrescens* Howell
White-footed mouse, *Peromyscus maniculatus* ssp.
Western bushy-tailed woodrat, *Neotoma cinerea occidentalis* (Baird)
Rat, *Rattus* sp.
Hermit thrush, *Hylochichla guttata* ssp.
Varied thrush, *Ixoreus naevius* ssp.
Golden-crowned sparrow, *Zonotrichia coronata* (Pallas)
Drag or clothing

Ixodes angustus Neumann
Scheffer's mole, *Scapanus orarius schefferi* Jackson
Hairy-tailed mole, *Parascalops breweri* (Backman)
Shrews, *Sorex* sp.
Short-tailed shrew, *Blarina brevicauda talpoides* (Gapper)
Man, *Homo sapiens* ssp.
Dog, *Canis familiaris*
Cat, *Felis domestica*
Pika, *Ochotona princeps* ssp.
Rabbit, *Lepus* sp.
Northwestern chipmunk, *Tamias striatus lysteri* (Richardson)
Lake Superior chipmunk, *Eutamias minimus neglectus* (Allen)
Southern red squirrel, *Tamiasciurus hudsonicus loquax* (Bangs)
Vancouver red squirrel, *Tamiasciurus hudsonicus vancouverensis* Allen
Northwestern red-bellied squirrel, *Tamiasciurus douglasii* Audubon and Bachman
Flying squirrel, *Glaucomys sabrinus* ssp.
White-footed mouse, *Peromyscus maniculatus* ssp.
Northern deer mouse, *Peromyscus leucopus novaboracensis* (Fischer)
Western bushy-tailed woodrat, *Neotoma cinerea occidentalis* (Baird)
Cooper's lemming mouse, *Synaptomys c. cooperi* Baird
Red backed mouse, *Clethrionomys gapperi* ssp.
Drummond's meadow mouse, *Microtus pennsylvanicus drummondi* (Audubon and Bachman)
Rat, *Rattus* sp.
Jumping mouse, *Zapus* sp.

Ixodes soricis Gregson
Vagrant shrew, *Sorex vagrans* ssp.
Cinereus shrew, *Sorex cinereus* ssp.
Dusky shrew, *Sorex obscurus* ssp.

Ixodes ochotonae Gregson
Pika, *Ochotona princeps* ssp.
White-footed mouse, *Peromyscus maniculatus* ssp.
Western bushy-tailed woodrat, *Neotoma cinerea occidentalis* (Baird)
Meadow mouse, *Microtus* sp.

Ixodes texanus Banks
Pacific raccoon, *Procyon lotor pacifica* (Merriam)
Eastern raccoon, *Proyon l. lotor* (Linnaeus)
Dog, *Canis familiaris*
Weasels (genus unknown)
Mink, *Mustela vison* ssp.
Pallid yellow-bellied marmot, *Marmota flaviventris avara* (Bangs)
Tree squirrel (genus unknown)

Ixodes hearlei Gregson
Streator's red squirrel, *Tamiasciurus hudsonicus streatori* Allen

Ixodes marxi Banks
Cat, *Felis domestica*
Snowshoe rabbit, *Lepus americanus* ssp.
Southern red squirrel, *Tamiasciurus hudsonicus loquax* (Bangs)
Northeastern gray squirrel, *Sciurus carolinensis leucotis* (Gapper)
Flying squirrel, *Glaucomys sabrinus* ssp.

Ixodes rugosus Bishopp
Mountain coyote, *Canis latrans* ssp.
Puget Sound spotted skunk, *Spilogale phenax olympica* (Elliot)

Ixodes marmotae Cooley and Kohls
Pallid yellow-bellied marmot, *Marmota flaviventris avara* (Bangs)
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Western bushy-tailed woodrat, *Neotoma cinerea occidentalis* (Baird)

Ixodes cookei Packard
Man, *Homo sapiens* ssp.
Eastern raccoon, *Procyon l. lotor* (Linneaus)
Dog, *Canis familiaris*
Cat, *Felis domestica*
Pine marten, *Martes a. americana* (Turton)
Fisher, *Martes p. pennanti* (Erxleben)
Mink, *Mustela vison* ssp.
Eastern striped skunk, *Mephitis m. nigra* (Peale and Beauvois)
Woodchuck, *Marmota monax* ssp.
Eastern Canada porcupine, *Erethizon d. dorsatum* (Linnaeus)
Cow
Snowy owl, *Nyctea nyctea*

Ixodes kingi Bishopp
Dog, *Canis familiaris*
Cat, *Felis domestica*
Weasels (genus unknown)
Badger, *Taxidea taxis* ssp.
Richardson's ground squirrel, *Citellus richardsoni* (Sabine)

Ixodes sculptus Neumann
Prairie long-tailed weasel, *Mustela frenata longicauda* Bonaparte
Badger, *Taxidea taxus* ssp.
White-tailed jack rabbit, *Lepus townsendii companius* Hollister
Franklin's ground squirrel, *Citellus franklini* (Sabine)
Striped ground squirrel, *Citellus tridecemlineatus* ssp.
Richardson's ground squirrel, *Citellus richardsoni* (Sabine)
Columbian ground squirrel, *Citellus c. columbianus* (Ord)
Pocket gopher, *Thomomys talpoides* ssp.

Ixodes muris Bishopp and Smith
Eastern woodland jumping mouse, *Napaeozapus i. insignis* (Miller)

Ixodes auritulus Neumann
Meadow mouse, *Microtus* sp.
Bald eagle, *Haliaeetus* sp.
Grouse (genus unknown)
Steller's jay, *Cyanocitta stelleri*
Crow, *Corvus brachyrhynchos*
Tree creeper, *Certhia familiaris* ssp.
Varied thrush, *Ixoreus naevius* ssp.
Junco, *Junco* sp.
Golden-crowned sparrow, *Zonotrichia coronata* (Pallas)

Ixodes signatus Birula
Cormorant, *Phalacrocorax* sp.
Rosy finch, *Leucosticte tephrocotis* ssp.

Ixodes uriae White
Cormorant, *Phalacrocorax* sp.
Atlantic puffin, *Fratercula arctica*
Common murre, *Uria aalge* ssp.
Razor-billed auk, *Alca torda*

Ixodes banksi Bishopp
Canada beaver, *Castor c. canadensis* Kuhl

GLOSSARY OF COLLECTORS

A.B.....The late Allan Brooks, artist and naturalist, Okanagan Landing, B.C.

A.D.....The late Alex. Dennis, formerly of the field crop insect laboratory, Vernon, B.C.

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A.L.S. .....A. L. Stewart

A.U.M. .....?

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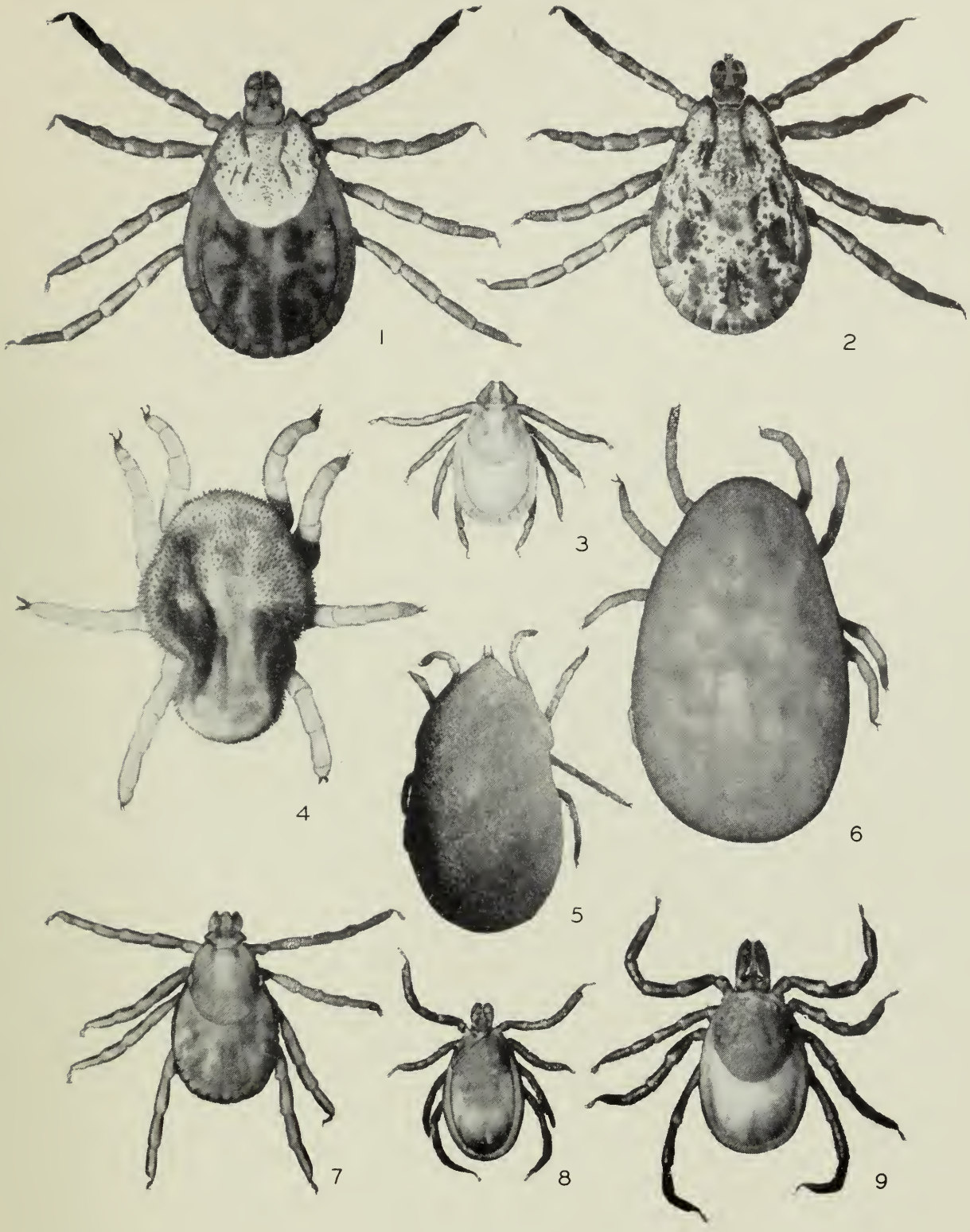


PLATE I

Photographs of representatives of Canadian genera of ticks.

Fig. 1. *Dermacentor andersoni* Stiles, female.

Fig. 2. *D. andersoni* Stiles, male.

Fig. 3. *Haemaphysalis leporis-palustris* (Packard), female.

Fig. 4. *Otobius megnini* (Dugès), nymph.

Fig. 5. *Ornithodoros hermsi* Wheeler, Herms, and Meyer, adult (nymphs, adults, and sexes all similar).

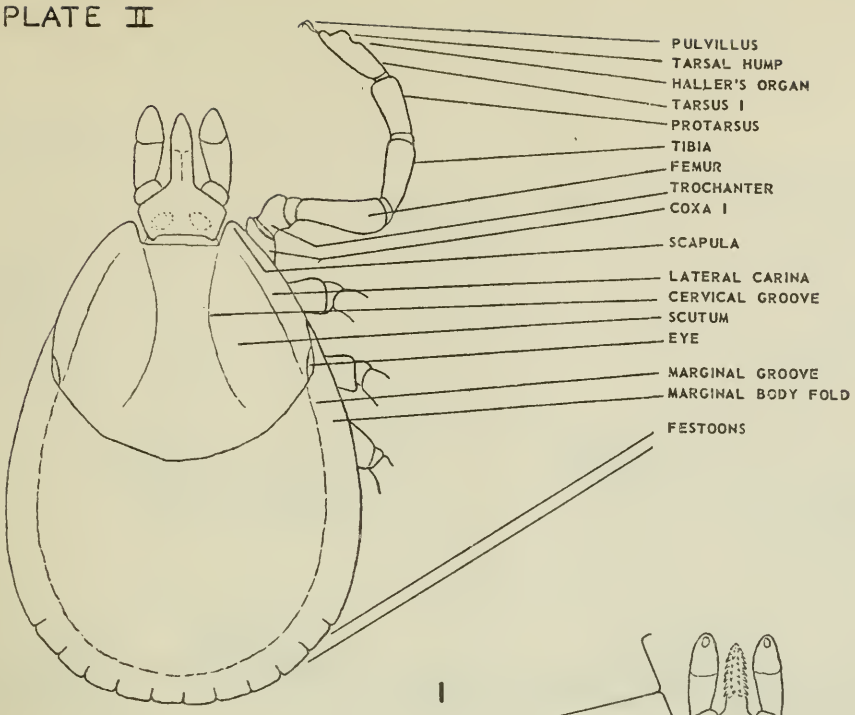
Fig. 6. *Argas persicus* (Oken), adult (nymphs, adults, and sexes all similar).

Fig. 7. *Rhipicephalus sanguineus* (Latreille), female.

Fig. 8. *Ixodes pacificus* Cooley and Kohls, male.

Fig. 9. *I. pacificus* Cooley and Kohls, female.

PLATE II



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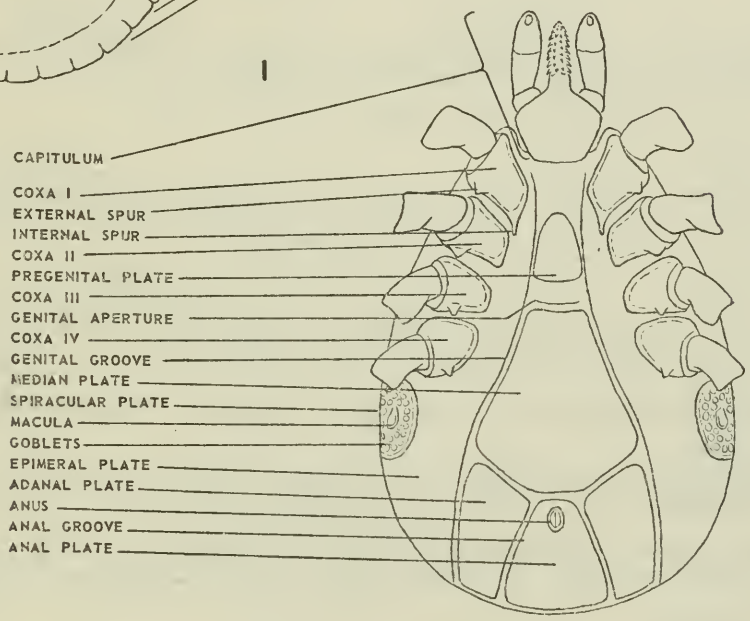

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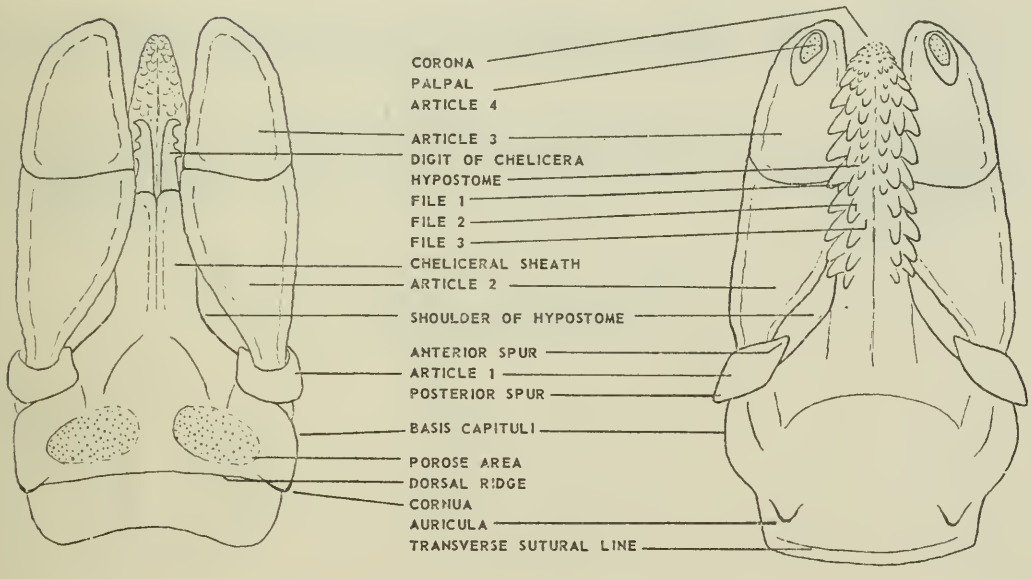

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PLATE II

Diagramatic illustrations of the external anatomy of an ixodid tick.

Fig. 1. Dorsal view of female.
Fig. 2. Ventral view of male.
Fig. 3. Dorsal view of female capitulum.
Fig. 4. Ventral view of female capitulum.

Figs. 1-17. Salient features of argasid ticks of Canada (scutum absent; capitulum ventral; integument leathery and pebbled, or spiny).

1-8. Genus *Argas* (lateral suture present).

1-4, *A. persicus.*

1, Outline of adult (body convex). 2, Portion of lateral suture (markings quadrangular). 3, Tarsus of leg I (dorsal protuberance mild). 4, Ventral view of capitulum (hypostome notched; post-palpal hairs present).

5-8, *A. reflexus.*

5, Outline of adult (body reflexed). 6, Portion of lateral suture (markings striate). 7, Tarsus of leg I (dorsal protuberance prominent). 8, Ventral view of capitulum (hypostome rounded; post-palpal hairs absent).

9-11. Genus *Ornithodoros* (no lateral suture; hypostome well developed).

9-11, *O. hermsi.*

9, Outline of adult (anterior end hoodlike). 10, Ventral view of capitulum (hypostome well developed). 11, Portion of integument (pebbled).

12-17. Genus *Otobius* (no lateral suture; nymphs spiny; adults with vestigial hypostome). 12, Outline of adult. 13, Ventral view of adult capitulum (hypostome vestigial).

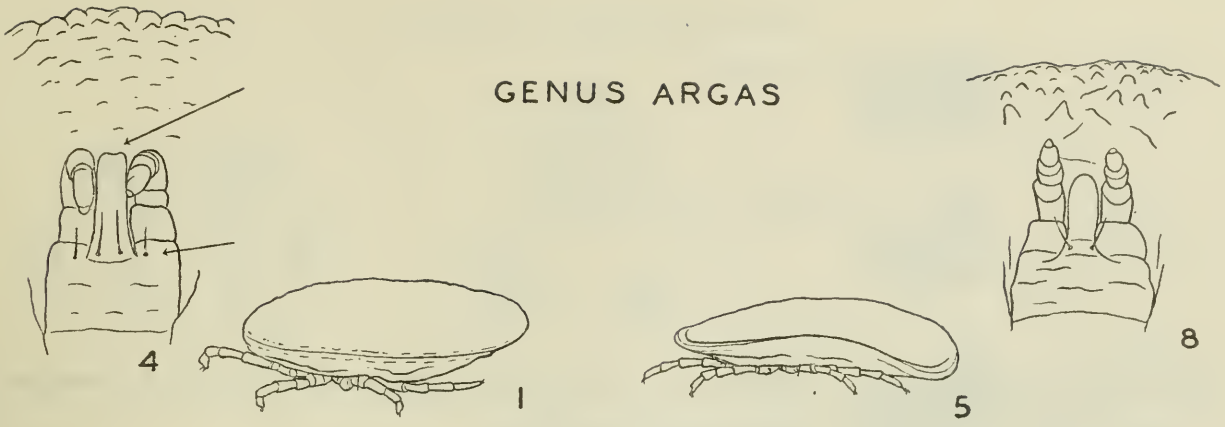
14-15, *O. megnini.*

14, Portion of adult integument (dorsal pits two or more times their diameter apart). 15, Outline of nymph (body panduriform; legs stout; anterior spines heavier than posterior).

16-17, *O. lagophilus.*

16, Portion of adult integument (dorsal pits one or less times their diameters apart). 17, Outline of nymph (body less panduriform than in *megnini*; legs moderate; spines of body all similar).

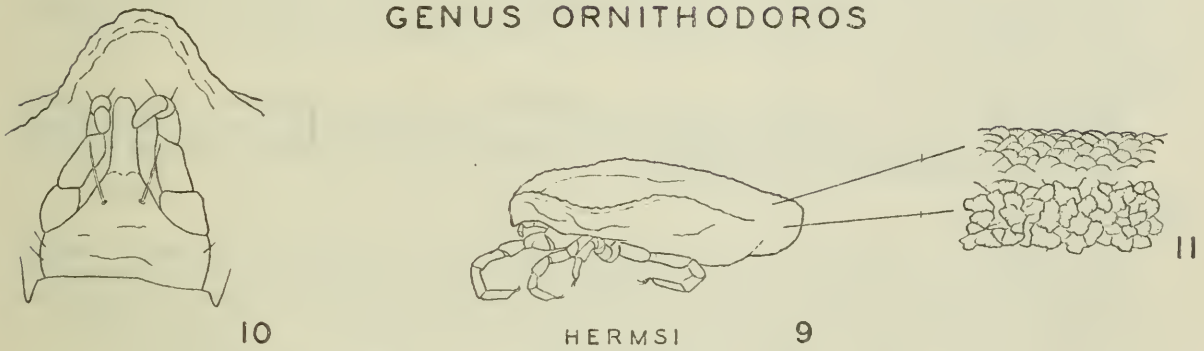
GENUS ARGAS



PERSICUS

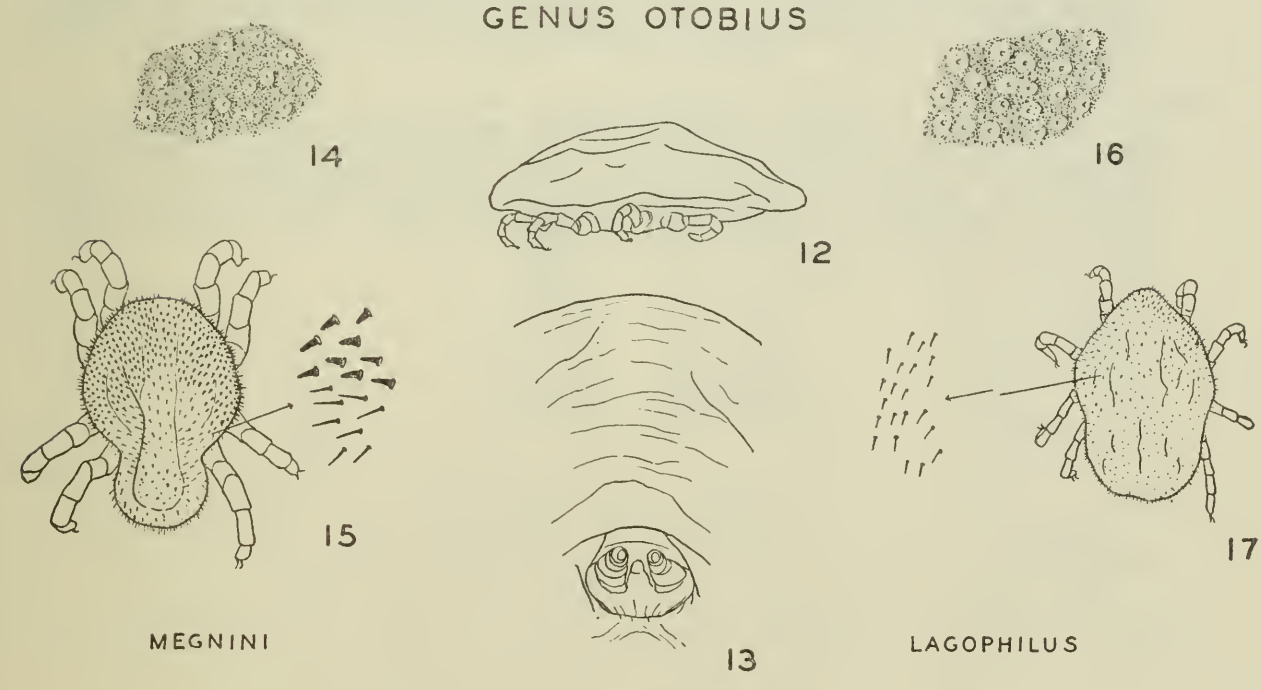
REFLEXUS

GENUS ORNITHODOROS



HERMSI

GENUS OTOBIUS



MEGNINI

LAGOPHILUS

Figs. 18-214. Salient features of ixodid ticks of Canada (scutum present; capitulum terminal; integument smooth).

18-24. Genus *Dermacentor* (ornate ticks; coxa I bifid).

18, Dorsal view of capitulum (outline of basis rectangular). 19, Coxa I (bifid). 20, Posterior ventral view of body (festoons present; anal groove posterior to anus). 21, Scutum of female (ornate).

22, *D. albipictus*. Spiracle of adult (goblets coarse) and coxa IV (external spur present) and dorsal view of capitulum (no basal spurs) of nymph.

23, *D. variabilis*. Spiracle of adult (goblets fine) and coxa IV (external spur absent) and dorsal view of capitulum (basal spurs directed backwards) of nymph.

24, *D. andersoni*. Spiracle of adult (goblets medium; dorsal prolongation present) and coxa IV (external spur faint) and dorsal view of capitulum (basal spurs directed outwards) of nymph.

25-27. Genus *Haemaphysalis* (inornate ticks; capitulum triangular; coxa I not bifid).

25, Dorsal view of capitulum (palps forming apex of triangle). 26, Coxa I. 27, Posterior ventral view of body (festoons present; anal groove posterior to anus).

28-31, *H. leporis-palustris*.

28, Ventral view of capitulum (hypostome dentition 3/3; cornua rounded; palpal margin reflexed). 29, Coxa I of female (coxal spur short). 30, Coxa I of male (coxal spur short). 31, Dorsal and ventral views of capitulum of nymph and larva (palpal margin reflexed; auriculæ prominent; basis rectangular).

32-35, *H. chordeilis*.

32, Ventral view of capitulum (hypostome dentition 5/5; cornua faint; palpal margin barely reflexed). 33, Coxa I of female (coxal spur longer than that of *leporis-palustris*). 34, Coxa I of male (coxal spur very long). 35, Dorsal and ventral views of capitulum of nymph and larva (palpal margin barely reflexed; auriculæ faint; basis hexagonal).

36-40. Genus *Rhipicephalus* (basis capituli hexagonal; eyes present; coxa I bifid).

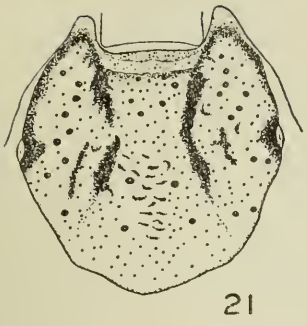
36-40, *R. sanguineus*.

36, Dorsal view of capitulum. 37, Coxa I. 38, Posterior ventral view of body (festoons present; anal groove posterior to anus; accessory plates present in male). 39, Scutum (eyes prominent). 40, Dorsal view of capitulum and scutum of nymph and larva (basis hexagonal; eyes present).

41-214. Genus *Ixodes* (anal groove anterior to anus; festoons absent; coxa I not bifid).

41, Dorsal views of capituli showing extremes within the genus (basis usually triangular in outline). 42, Coxa I showing extremes of internal and external spurs (from near absence to stout spines). 43, Posterior ventral view of body (anal groove anterior to anus). 44, Outlines of scuta showing variations in shape (length measured back from tip of scapula). 45, Ventral views of nymph and larva (note absence of genital apertures and of the fourth pair of legs in larva).

GENUS DERMACENTOR



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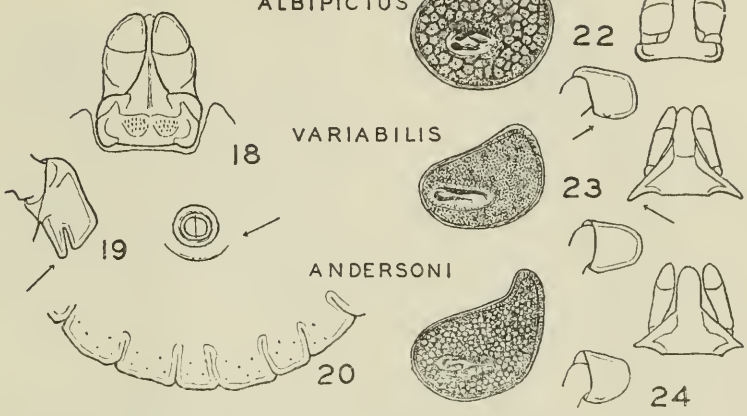
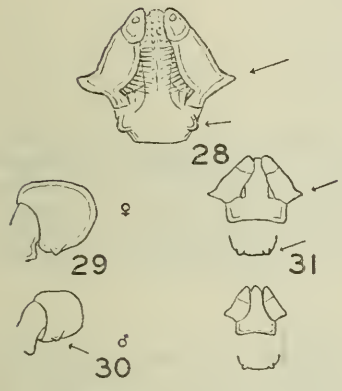
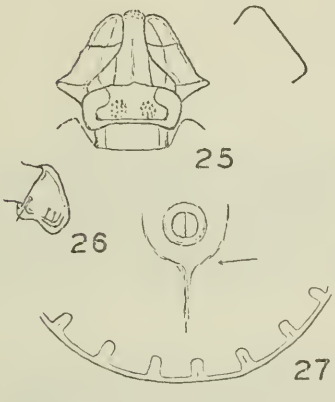
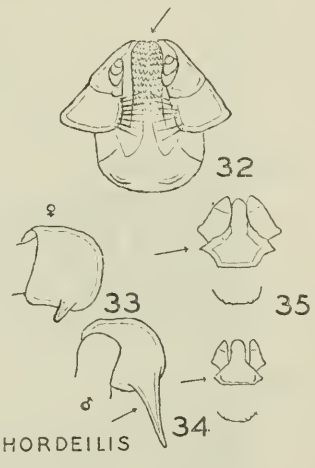


GENUS HAEMAPHYSALIS



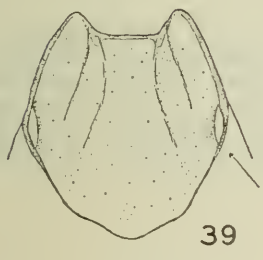
LEPORIS-PALUSTRIS





CHORDEILIS

GENUS RHIPICEPHALUS



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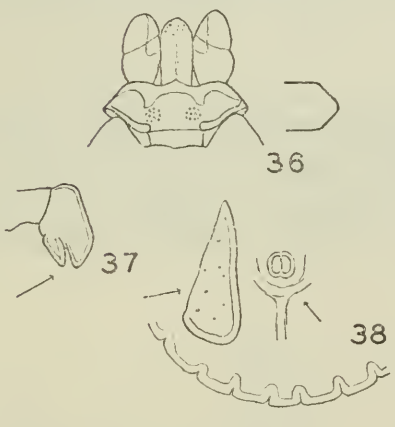
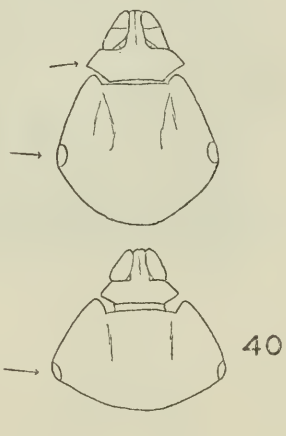
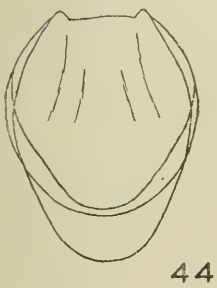
SANGUINEUS





GENUS IXODES



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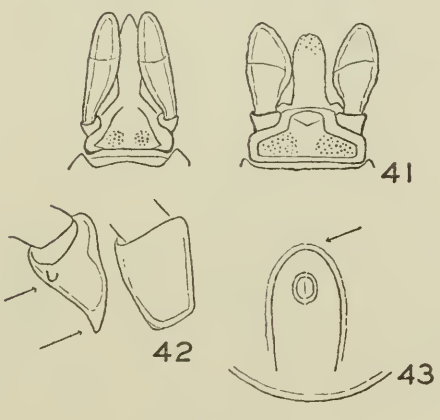
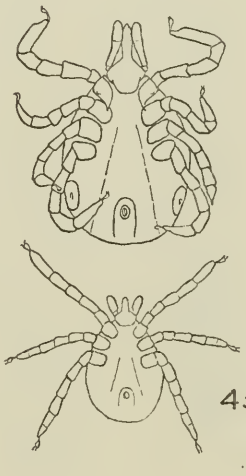




46-55, *I. pacificus.*

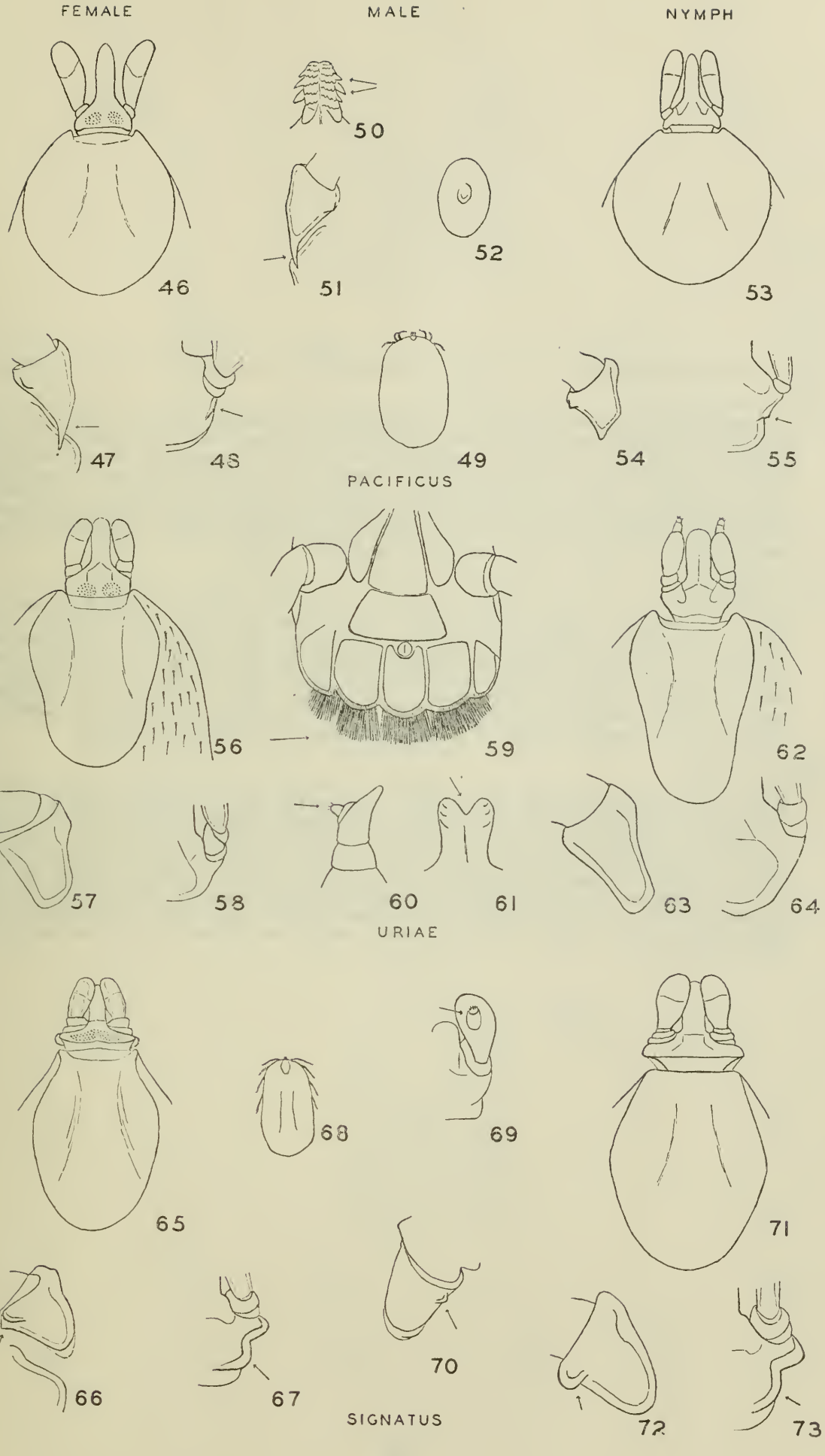
46, Dorsal view of female scutum and capitulum (scutum nearly circular). 47, Coxa I of female (internal spur long and sharp). 48, Ventral view of basis capituli of female (auriculæ shelf-like). 49, Outline of engorged female (bean-shaped). 50, Hypostome of male (lateral denticles present). 51, Coxa I of male (internal spur long and sharp). 52, Spiracle of male (oval). 53, Dorsal view of scutum and capitulum of nymph (scutum nearly circular). 54, Coxa I of nymph. 55, Ventral view of basis capituli of nymph (auriculæ shelf-like).

56-64, I. *uriæ.*

56, Dorsal view of female scutum and capitulum (body hairy). 57, Coxa I of female (spurs absent). 58, Ventral view of basis capituli of female (auriculæ absent). 59, Posterior ventral view of male (terminal fringe of spines present). 60, Palpus of male (article 4 back from end of article 3). 61, Hypostome of male (vestigial and notched). 62, Dorsal view of scutum and capitulum of nymph (scutum punctate). 63, Coxa I of nymph (spurs absent). 64, Ventral view of basis capituli of nymph (auriculæ absent).

65-73, *I. signatus.*

65, Dorsal view of scutum and capitulum of female (scutum longer than broad). 66, Coxa I of female (only external spurs present). 67, Ventral view of basis capituli of female (auriculæ as rounded extensions). 68, Outline of engorged female (elongate). 69, Basis capituli of male (article 4 back from end of article 3). 70, Coxa I of male (only external spur present). 71, Dorsal view of scutum and capitulum of nymph (basis broad and short). 72, Coxa I of nymph (only external spur present). 73, Ventral view of basis capituli of nymph (auriculæ as broadly rounded extensions).


FEMALE
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PACIFICUS
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URIAE
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SIGNATUS

74-101, *texanus-hearlei-marxi* group (coxal spines faint; scuta about as broad as long).

74-82, *I. texanus.*

74, Dorsal view of female scutum and capitulum (scutum as broad as long). 75, Coxa I of female (internal spur small). 76, Ventral view of basis capituli of female (auriculæ absent; shoulders of hypostome humped). 77, Outline of engorged female (oval). 78, Ventral plates of male (punctations less distinct on median plate than anal; median and anal plates equal in length; spiracle relatively large (see Fig. 87). 79, Coxa I of male (internal spur small). 80, Dorsal view of scutum and capitulum of nymph (scutum widest near middle). 81, Coxa I of nymph (internal spur small). 82, Ventral view of basis capituli of nymph (shoulders of hypostome humped).

83-91, *I. hearlei.*

83, Dorsal view of scutum and capitulum of female (scutum as broad as long). 84, Coxa I of female (internal spur small). 85, Ventral view of basis capituli of female (auriculæ absent; shoulders of hypostome sloping). 86, Outline of engorged female (elongate). 87, Ventral plates of male (punctations less distinct on median than on anal plate; median and anal plates equal in length; spiracle small (see Fig. 78)). 88, Coxa I of male (internal spur small). 89, Dorsal view of scutum and capitulum of nymph (scutum widest near middle). 90, Coxa I of nymph (internal spur small). 91, Ventral view of basis capituli of nymph (shoulders of hypostome sloping).

92-101, *I. marxi.*

92, Dorsal view of scutum and capitulum of female (scutum longer than broad). 93, Coxa I of female (internal spur small). 94, Ventral view of basis capituli of female (auricula as rounded hump). 95, Outline of engorging female (oval). 96, Ventral plate of male (punctations less distinct on median than on anal plate; median and anal plates equal in length; spiracle small (see Fig. 78)); after Cooley and Kohls, 1945. 97, Basis capituli of male (transverse wrinkles present); after Cooley and Kohls, 1945. 98, Coxa I of male (internal spur small); after Cooley and Kohls, 1945. 99, Dorsal view of scutum and capitulum of nymph (scutum longer than wide). 100, Coxa I of nymph (internal spur small). 101, Ventral view of basis capituli of nymph (auricula posterior to middle of basis).

FEMALE

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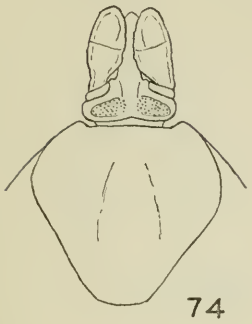
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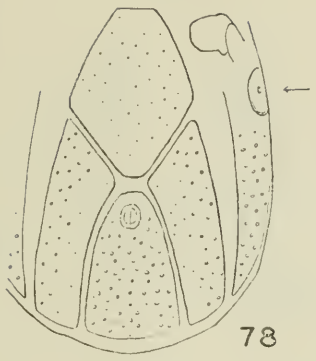
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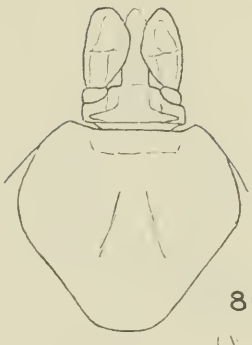
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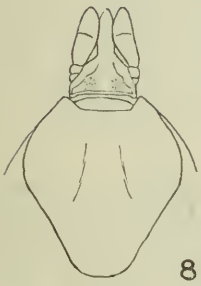
TEXANUS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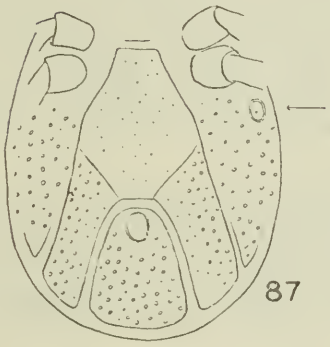
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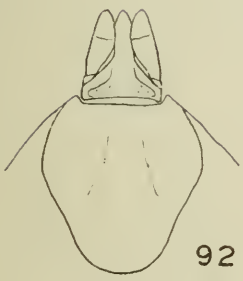
HEARLEI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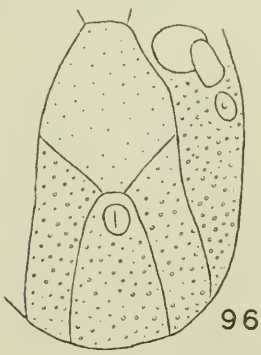
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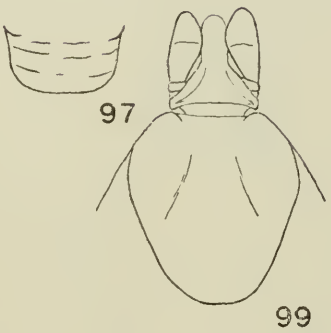
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MARXI

102-128, *angustus ochotonæ-soricis* group (coxal spurs moderately long; scuta definitely longer than broad).

102-110, *I. angustus.*

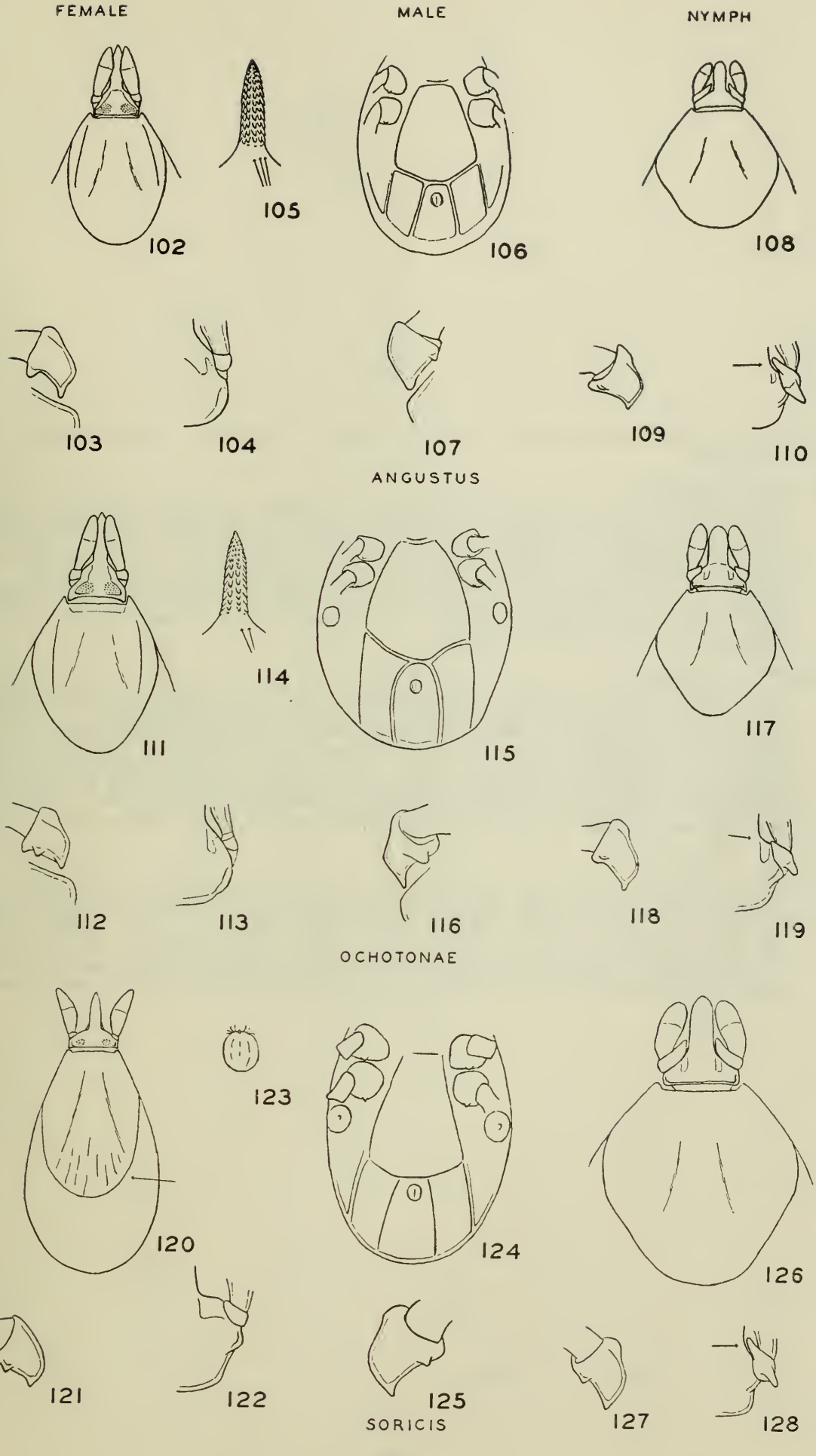
102, Dorsal view of scutum and capitulum of female. 103, Coxa I of female. 104, Ventral view of basis capituli of female (auricula absent). 105, Hypostome of female (dentition 3/3). 106, Basal plates of male (median plate longer than anal; adanal plates broader in front, their outer sides parallel; total length of male about 1·5 mm.). 107, Coxa I of male. 108, Dorsal view of scutum and capitulum of nymph. 109, Coxa I of nymph (both spurs about equal in length). 110, Ventral view of basis capituli of nymph (anterior and posterior horns present on palpal article 1).

111-119, *I. ochotonæ.*

111, Dorsal view of scutum and capitulum of female. 112, Coxa I of female. 113, Ventral view of basis capituli of female (auricula absent). 114, Hypostome of female (dentition 2/2). 115, Basal plates of male (medium and anal plates equal in length; punctations similar on all plates). 116. Coxa I of male. 117, Dorsal view of scutum and capitulum of nymph. 118, Coxa I of nymph (spurs equal in size). 119, Ventral view of basis capituli of nymph (only a posterior horn on palpal article 1).

120-128, *I. soricis.*

120, Dorsal view of scutum and capitulum of female; (posterior portion with longitudinal wrinkles). 121, Coxa I of female. 122, Ventral view of basis capituli of female (auricula nearly absent). 123, Outline of engorged female (nearly spherical). 124, Basal plates of male (median plate longer than anal; adanal plates broader in front; total length of male about 0·1 mm.). 125, Coxa I of male. 126, Dorsal view of scutum and capitulum of nymph. 127, Coxa I of nymph. 128, Ventral view of basis capituli of nymph (anterior and posterior horns present on palpal article 1).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OCHOTONAE
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SORICIS

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129-155, *spinipalpis-auritulus-muris* group (auriculæ retrograde; external coxal spurs prominent).

129-138, *I. spinipalpis.*

129, Dorsal view of scutum and capitulum of female. 130, Coxa I of male (internal spur long; external spur stout). 131, Ventral view of basis capituli of female (auricula sharp and hornlike). 132, Hypostome of male (lateral denticles present). 138, Ventral view of basis capituli of male (auricula sharp and shelf-like). 134, Spiracle of male (circular). 135, Coxa I of male (internal spur long but blunt (see Fig. 151)). 136, Dorsal view of scutum and capitulum of nymph (lateral carinæ present; outer margin of palps concave). 137, Coxa I of nymph. 133, Ventral view of basis capituli of nymph (auricula as a triangular projection).

139-146, *I. auritulus.*

139, Dorsal view of scutum and capitulum of female (scutum as broad as long). 140, Coxa I of female (external spur stout and greater than internal spur). 141, Ventral view of basis capituli of female (auricula large, rounded; anterior spur on palpal article 1). 142, Ventral plates of male (median plate longer than anal; adanal plates broader at anterior end; spiracles small). 143, Coxa I of male (external spur absent; internal spur faint). 144, Dorsal view of scutum and capitulum of nymph (cornua prominent). 145, Coxa I of nymph (external spur longer than internal). 146, Ventral view of basis capituli of nymph (auricula large and rounded; anterior spur on palpal article 1).

147-155, *I. muris.*

147, Dorsal view of scutum and capitulum of female. 148, Coxa I of female (internal spur long and pointed). 149, Ventral view of basis capituli of female (auricula blunt). 150, Ventral plates of male (median plate longer than anal). 151, Coxa I of male (internal spur moderate). 152, Hypostome of male (apex notched). 153, Dorsal view of scutum and capitulum of nymph. 154, Coxa I of nymph (internal and external spurs well developed). 155, Ventral view of basis capituli of nymph (auricula rounded).

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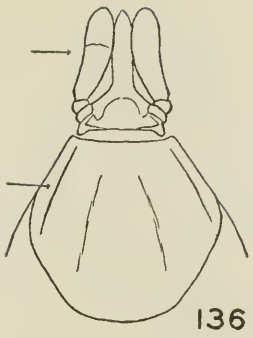

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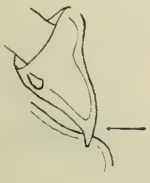

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SPINIPALPIS

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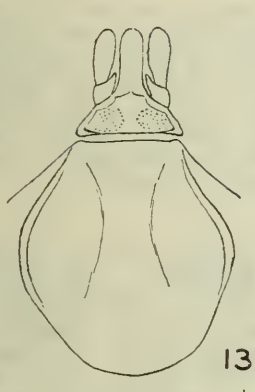

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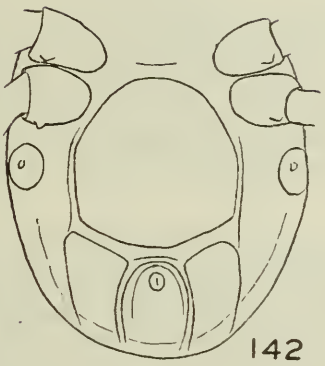

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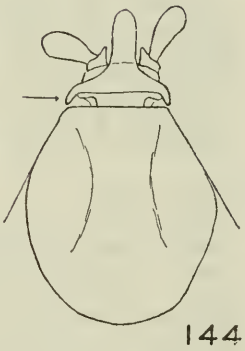

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AURITULUS

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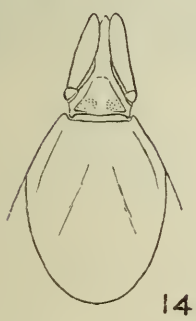

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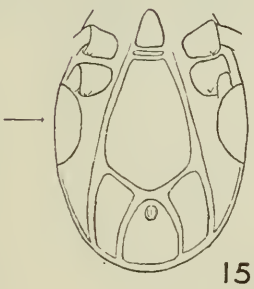

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MURIS

50988—6½

156-215, *sculptus-cookei-marmotæ-rogosus-kingi* group (scutum usually about as broad as long; internal spurs of coxa I long).

156-164, *I. sculptus.*

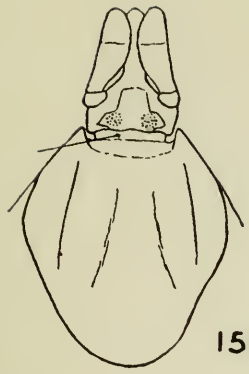
156, Dorsal view of scutum and capitulum of female (posterior margin of basis sinuous). 157, Coxa I of female (interior spur robust, rodlike, and blunt). 158, Outline of engorged female (oval). 159, Ventral view of basis capituli of female (auricula faint). 160, Basal plates of male (adanal plates broader in front; plates with distinct punctations). 161, Coxa I of male (internal spur longer than external). 162, Dorsal view of scutum and capitulum of nymph (scutum widest near middle; cornua long). 163, Coxa I of nymph (internal spur rodlike and rounded). 164, Ventral view of basis capituli of nymph (anterior and posterior horns of palpal article 1 present).

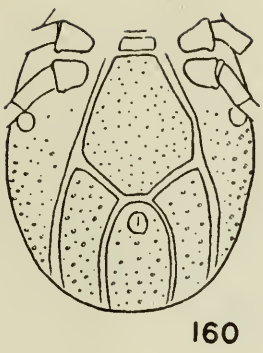
165-174, *I. cookei.*

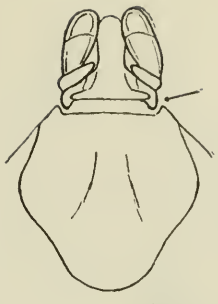
165, Dorsal view of scutum and capitulum of female (posterior margin of basis straight; lateral carinæ present). 166, Coxa I of female (internal spur tapering). 167, Ventral view of basis capituli of female (shoulders of hypostome sloping). 168, Tarsus of leg I of female (tarsal hump present). 169, Hypostome of male (median denticles as diagonal crenulations); after Cooley and Kohls, 1945. 170, Scutum of male (marginal grooves moderately straight (see Fig. 189)); after Cooley and Kohls, 1945. 171, Coxa I of male (internal spur sharp). 172, Dorsal view of scutum and capitulum of nymph (scutum broader than long). 173, Coxa I of nymph (internal spur tapering). 174, Ventral view of basis capituli of nymph (auricula shelf-like).

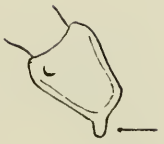
175-184, *I. marmotæ.*

175, Dorsal view of scutum and capitulum of female (lateral carinæ present). 176, Coxa I of female (internal spur rounded). 177, Ventral view of basis capituli of female. 178, Hypostome of female (teeth curved). 179, Tarsus of leg I of female (tarsal hump present). 180, Ventral plates of male (median plate longer than broad; median and anal plates equal in length; punctations equally distinct on all plates). 181, Coxa I of male (internal spur longer than external). 182, Dorsal view of scutum and capitulum of nymph (scutum widest near anterior end). 183, Coxa I of nymph (internal spur rounded). 184, Ventral view of basis capituli of nymph (anterior spur of palpal article 1 present).









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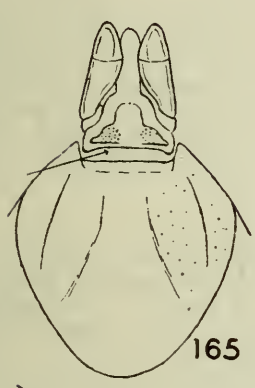
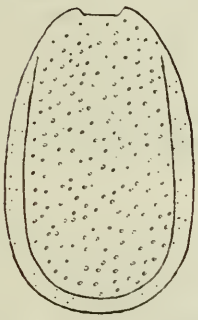
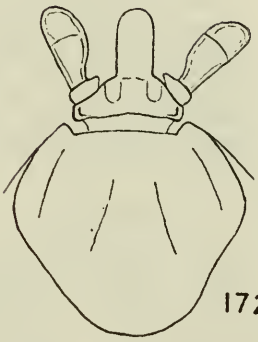
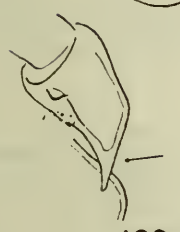
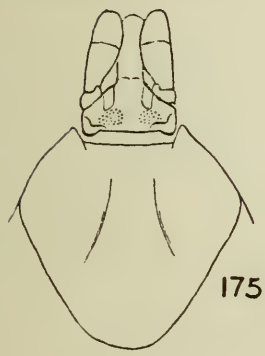


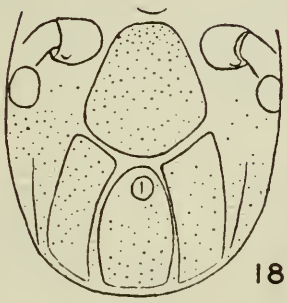


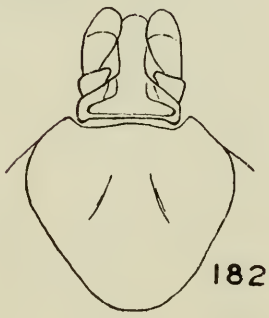


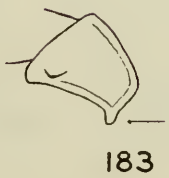


COOKEI









MARMOTAE

185-194, *I. rugosus.*

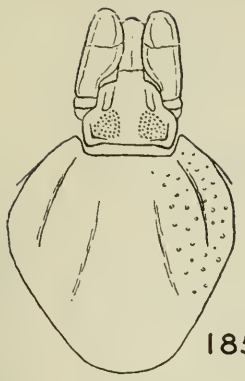
185, Dorsal view of scutum and capitulum of female (punctations present). 186, Coxa I of female (internal spur tapering, and pointed). 187, Outline of engorged female (pear-shaped). 188, Ventral view of basis capituli of female (auricula faint; shoulder of capitulum flattened). 189, Scutum of male (marginal grooves convex (see Fig. 170)); after Cooley and Kohls, 1945. 190, Hypostome of male (median denticles in lineal files (compare with Fig. 169)). 191, Coxa I of male (internal spur tapering, and pointed). 192, Dorsal view of scutum and capitulum of nymph. 193, Coxa I of nymph (spurs small and rounded). 194. Ventral view of basis capituli of nymph (posterior spur of palpal article 1 rounded and not retrograde).

195-204, *I. kingi.*

195, Dorsal view of scutum and capitulum of female (punctations present). 196, Coxa I of female (internal spur rounded). 197, Ventral view of basis capituli of female. 198, Outline of engorged female (spherical). 199, Hypostome of female (massive build; teeth conical (compare with Fig. 157)). 200, Ventral plates of male (median plates longer than anal; adanal plates of equal width at both ends). 201, Coxa I of male (internal spur rounded). 202, Dorsal view of scutum and capitulum of nymph (cornua prominent). 203, Coxa I of nymph. 204, Ventral view of basis capituli of nymph (auricula shelf-like; anterior spur of palpal article 1 absent, posterior spur present).

205-215, *I. banksi.*

205, Dorsal view of scutum and capitulum of female (cornua faint). 206, Coxa I of female. 207, Ventral view of basis capituli of female. 208, Tarsus of leg I of female (tarsal hump less pronounced than that of *I. cookei*). 209, Spiracle of female (large, compared to that of *I. cookei*). 210, Spiracle of female of *I. cookei,* same scale, for comparison. 211, Dorsal view of scutum and capitulum of nymph (cornua faint). 212, Coxa I of nymph. 213, Ventral view of basis capituli of nymph (anterior spur of palpal article 1 small). 214, Spiracle of nymph (large, compared to that of *I. cookei*). 215, Spiracle of nymph of *I. cookei,* same scale, for comparison.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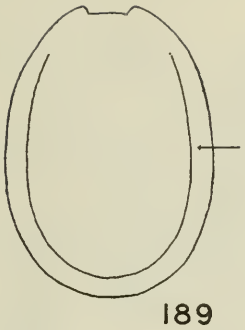
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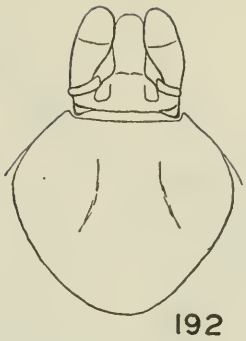
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RUGOSUS


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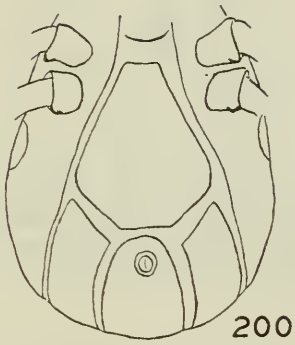
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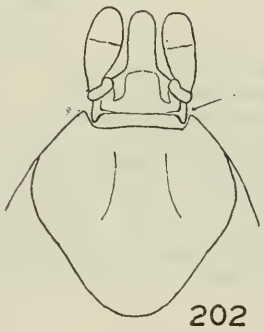
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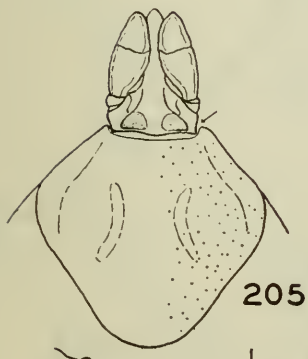
KINGI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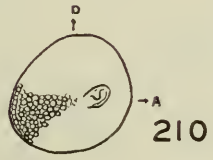

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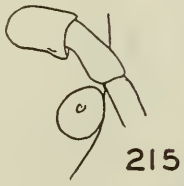
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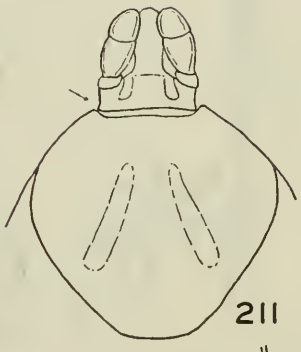
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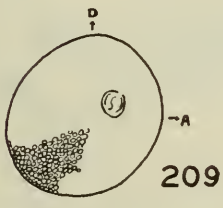

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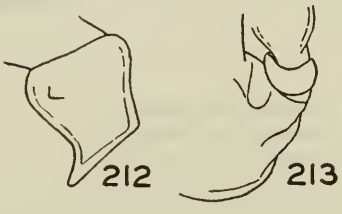
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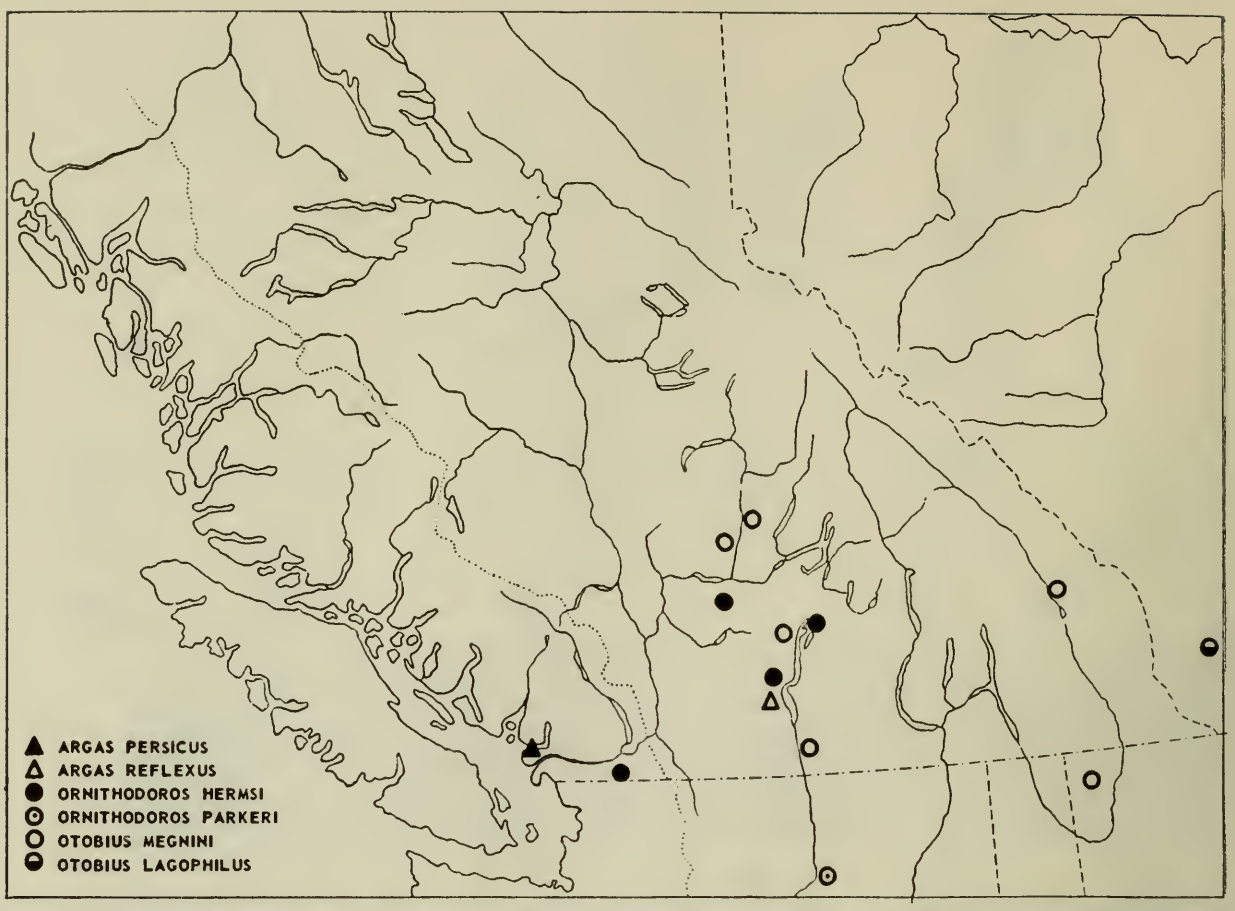
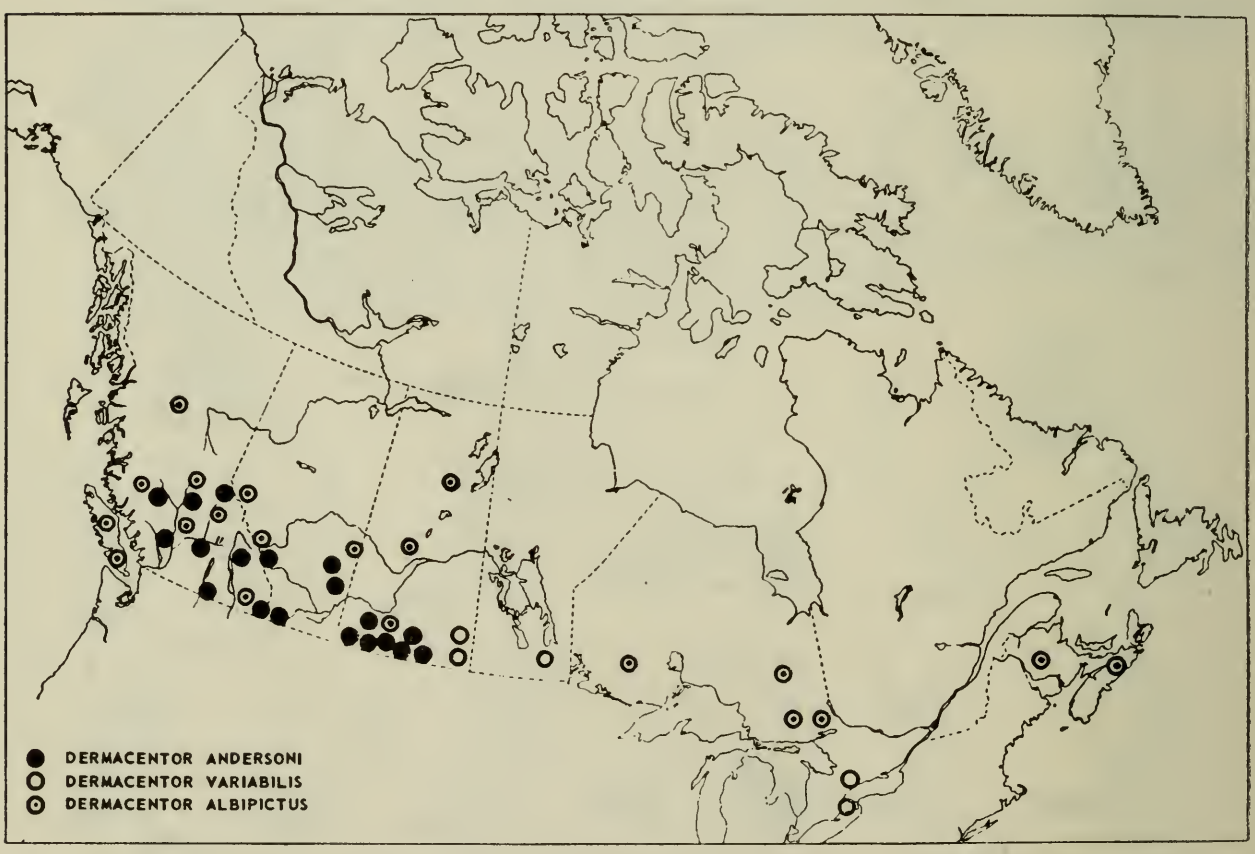
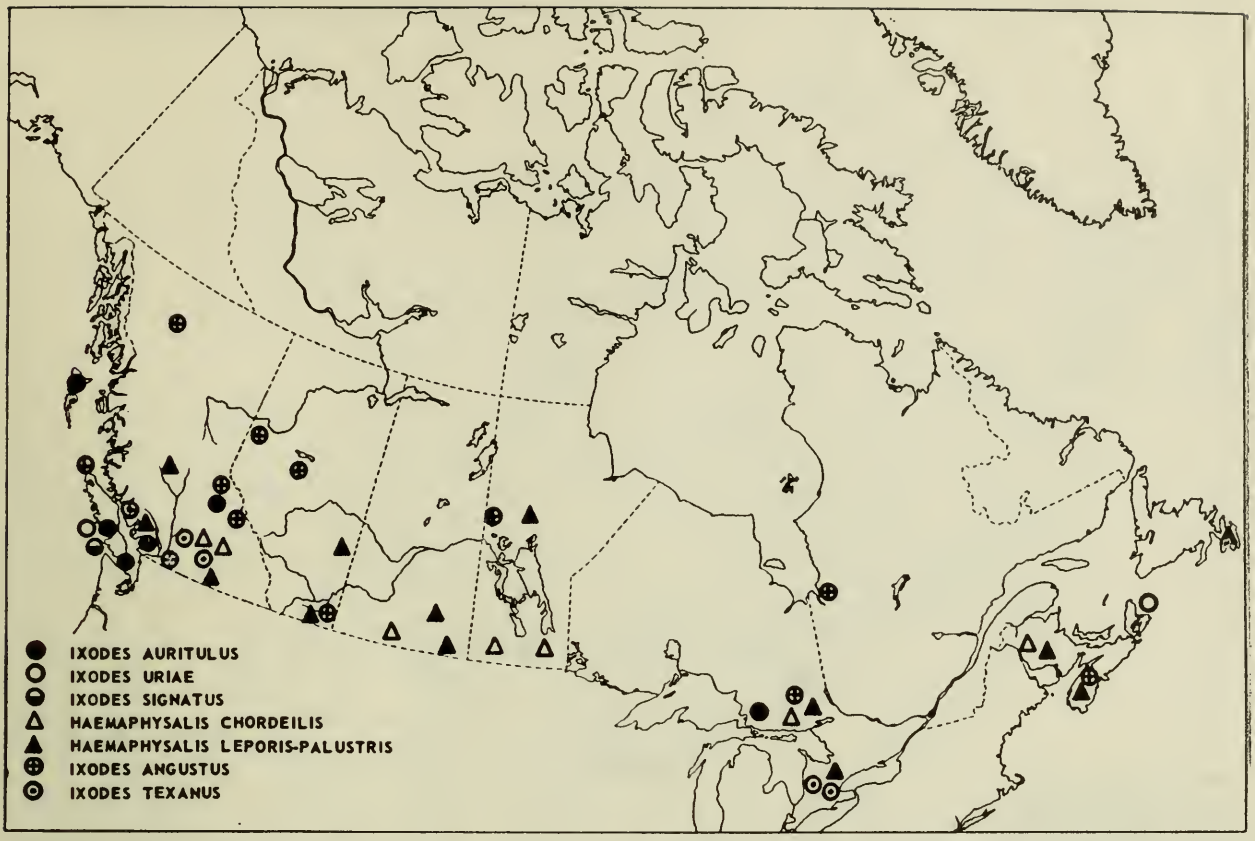
BANKSI



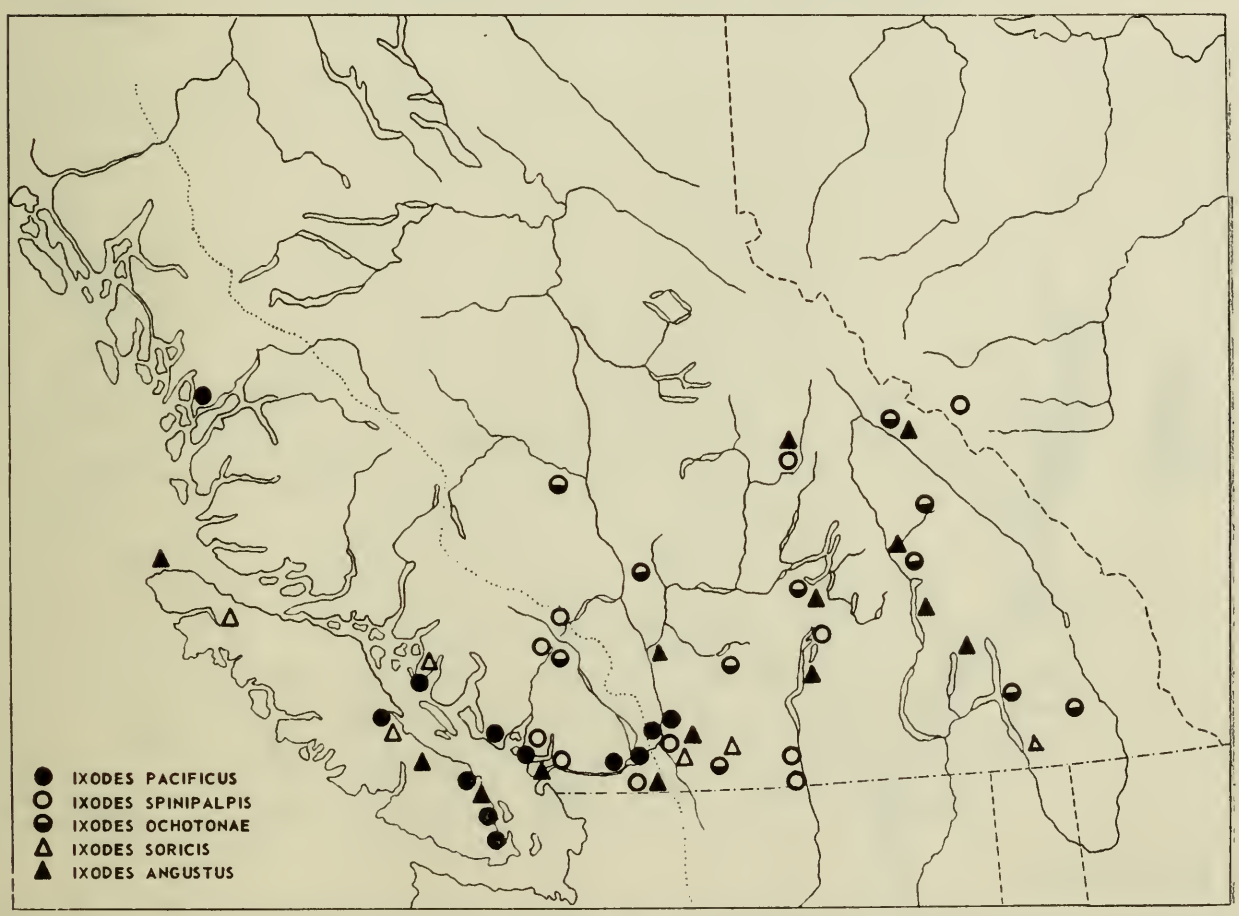
MAP I—Locality records of the argasid ticks *Argas persicus* (Oken), *A. reflexus* (Fabricius), *Ornithodoros hermsi* Wheeler, Herms, and Meyer, *O. parkeri* Cooley, *Otobius megnini* (Dugès), and *O. lagophilus* Cooley and Kohls.



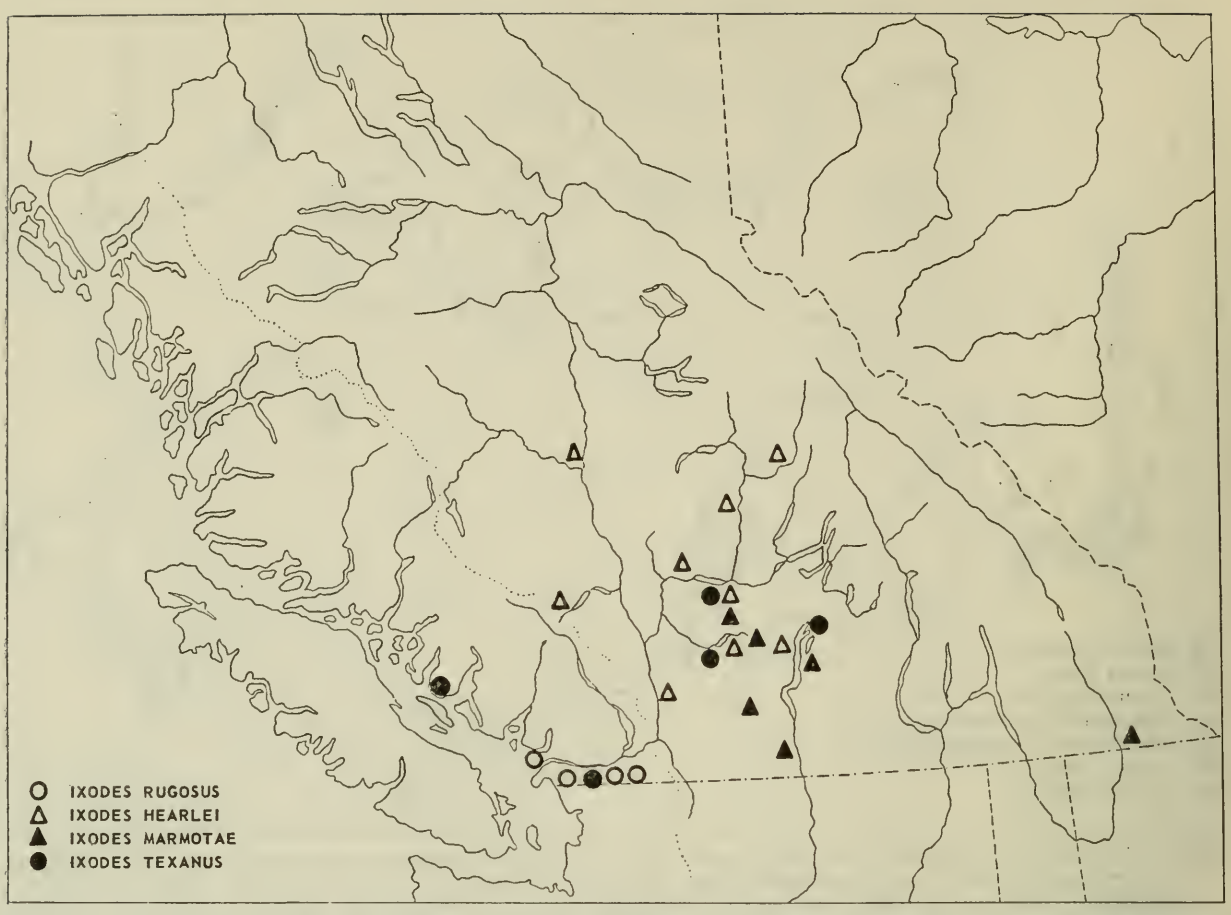
MAP II—Locality records of *Dermacentor andersoni* Stiles, *D. variabilis* (Say), and *D. albipictus* (Packard).



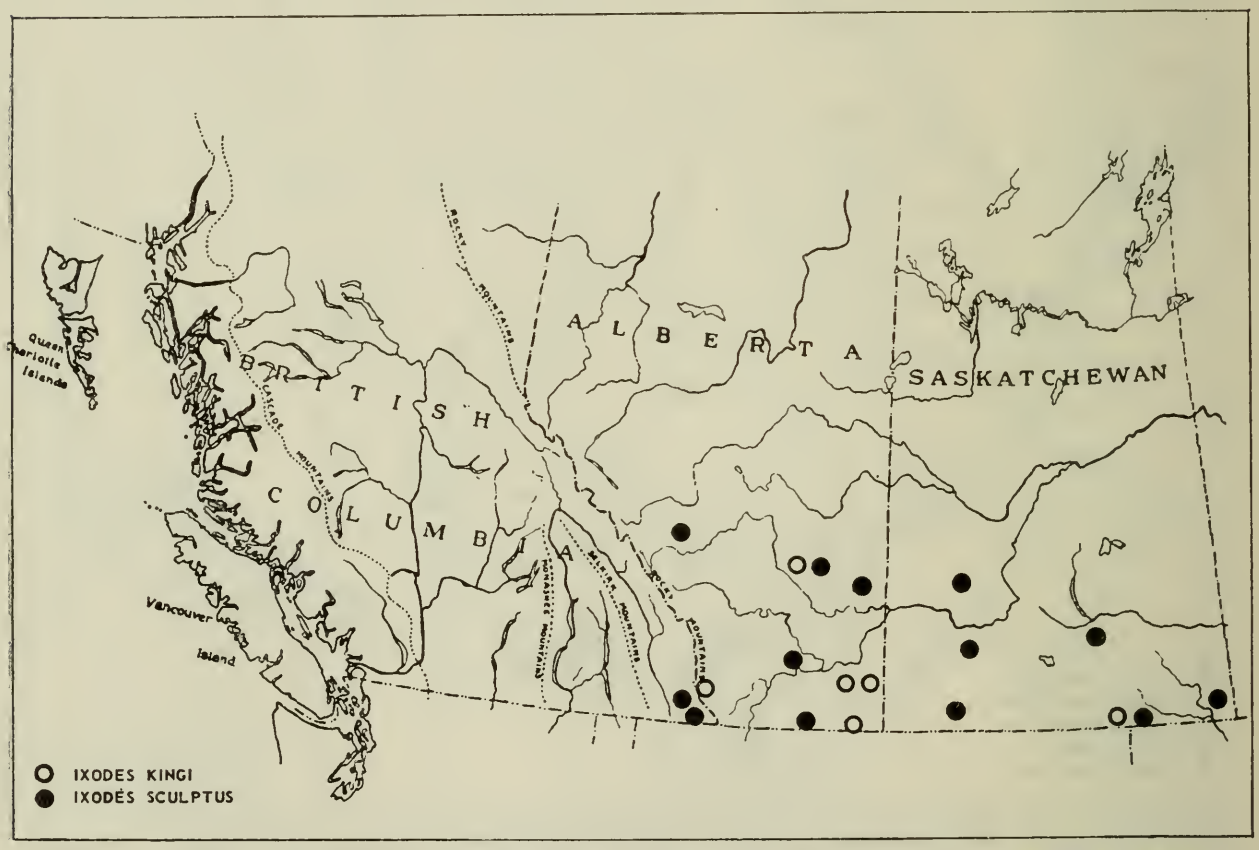
MAP III—Locality records of the bird ticks *Ixodes auritulus* Neumann, *I. uriæ* White, *I. signatus* Birula, and *Haemaphysalis chordeilis* (Packard); of the rabbit tick, *H. leporis-palustris* (Packard); and, for Eastern Canada only, of *I. angustus* Neumann and *I. texanus* Banks.



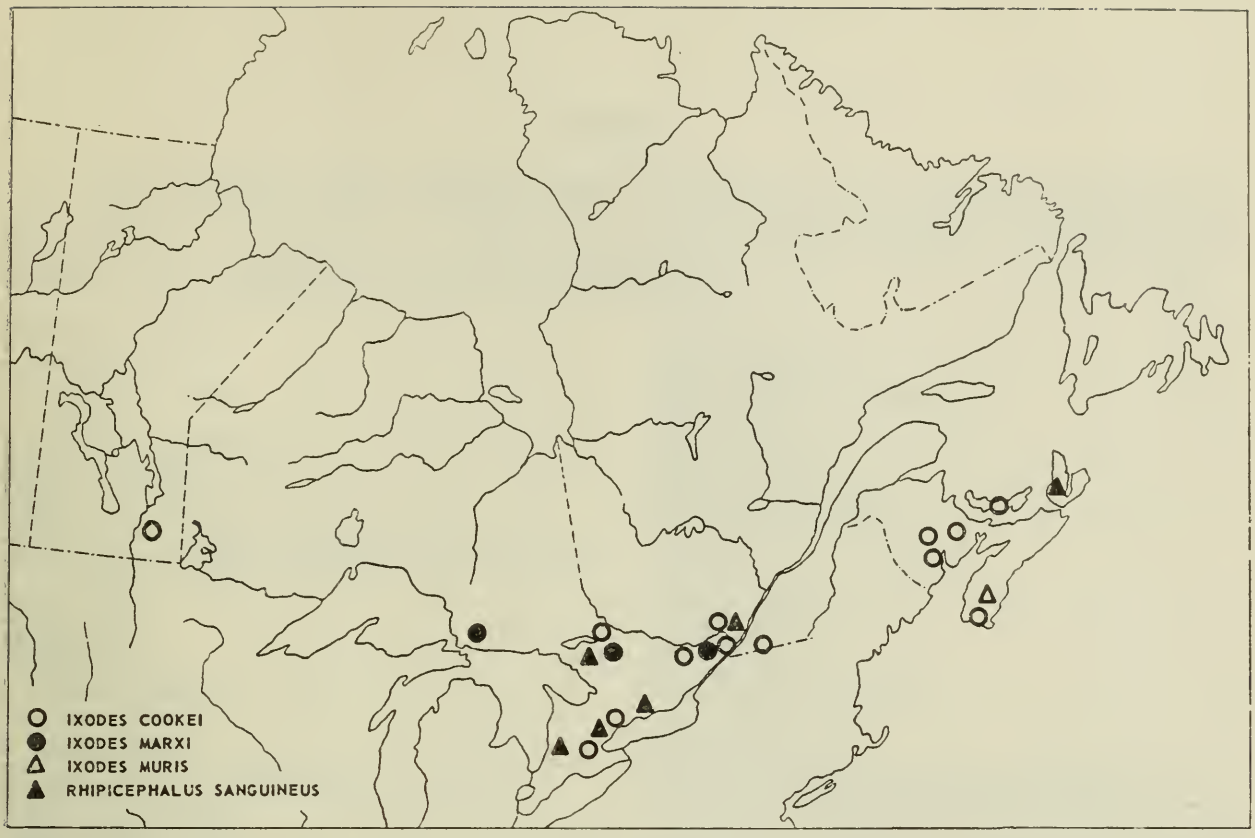
MAP IV—Locality records of *Ixodes pacificus* Cooley and Kohls, *I. spinipalpis* Nuttall, *I. ochotonæ* Gregson, *I. soricis* Gregson, and *I. angustus* Neumann (see also Map III).



MAP V—Locality records of *Ixodes rugosus* Bishopp, *I. hearlei* Gregson, *I. marmotæ* Cooley and Kohls, and *I. texanus* Banks (see also Map III).



MAP VI—Locality records of the prairie ticks *Ixodes kingi* Bishopp and *I. sculptus* Packard.



MAP VII—Locality records of the eastern ticks *Ixodes cookei* Packard, *I. marxi* Banks, *I. muris* Bishopp and Smith, and *Rhipicephalus sanguineus* (Latreille).

INDEX

The following index contains page references to all Ixodoidea quoted in this paper. Synonyms of names are italicized. References to definition of terms used in taxonomy, to tick-transmitted diseases, and to classes, orders, families, and genera of hosts are also supplied.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956